The SCIENTIFIC MONTHLY

desk

VOL. LXXIV NO. 2 FEBRUARY 1952

THE SCIENTIFIC MONTHLY

VOL. LXXIV FEBRUARY 1952 NO. 2

Contents

Established 1872 as *The Popular Science Monthly;* since 1915 an official publication of the American Association for the Advancement of Science.

Publication office, Business Press, Inc., 10 McGovern Ave., Lancaster, Pa. Orders for subscriptions and requests for change of address should be directed to the Circulation Department, A.A.A.S., 1515 Massachusetts Ave., N.W., Washington 5, D. C. Subscriptions: $7.50 per year; single copies 75 cents. Four weeks are required to effect change of address.

Address all correspondence concerning editorial matters and advertising to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. The editors are not responsible for loss or injury of manuscripts and photographs while in their possession or in transit; all manuscripts should be accompanied by return postage. The American Association for the Advancement of Science assumes no responsibility for the statements and opinions expressed by contributors.

 Entered as second-class matter at the Post Office at Lancaster, Pa., December 30, 1947, under the Act of March 3, 1879. Acceptance for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2) Section 34.40 P.L. & R. of 1948. Indexed in the *Reader's Guide to Periodical Literature*. The A.A.A.S. also publishes SCIENCE. Subscription and advertising rates on request.

Science and Technology

(From the Month's News Releases)

Electronic Marvels

Desk-Fax, developed by Western Union, is a foot-square facsimile telegraph machine that instantly and automatically sends telegrams written or typed on ordinary paper simply by the pushing of a button. To receive a telegram, special paper is necessary, and two buttons must be pushed. In case of confusion among the buttons, the machine refuses to function. Telegrams sent and received by this method are charged for at regular telegraph rates. It is expected that 10,000 machines will be in service by the end of 1952. Western Union has also announced the development of High-Speed Facsimile for the rapid communication of copy up to $8\frac{1}{2}'' \times 15''$ in size. According to company engineers, this giant gadget is capable of transmitting and recording in finished form 3,000 words of newsprint per minute, with no advance preparation or processing.

Speaking of Robots

In Sweden, Sture Ortenblad, secretary of the Association of Swedish Inventors, has designed Reflex, a robot clock that will provide a choice of timings over a period of more than 24 hours, making possible 50 advance-set connections and disconnections of radio sets, shop-window lights, electric stoves, or other electric apparatus. The patent to Reflex is held in Sweden by the Cooperative Union & Wholesale Society.

Fast Primer Coat

By the time a painter has finished applying a coat of Du Pont Sealer-Coater to a room, he can start with the finishing coat in the area where he began, for Sealer-Coater dries in less than two hours, or even in 20 minutes. It may be applied over dry wall construction, wallboard, oil-type flat wall paints or enamels, resin-emulsion paints, and old plaster. It cannot be used under rubber-base paints.

Underwater Television

Future salvage and other underwater operations may be completely planned before a diver goes down to do the work if a TV camera developed by the Navy's Bureau of Ships comes into common use. With suspended lights, ship personnel can make lengthy observations of the ocean bottom, or even film the televised picture for future reference.

Short Cut to a Nervous Breakdown

The Franklin Institute has renovated its famous Illusion Room and added new illusions to the 70-odd that have been features of the section since it was opened on April Fool's Day in 1949. One expected to create great interest is the rotating trapezoidal window. Viewing a foreshortened window with one eye, the observer sees the rotating window as swinging back and forth. If a hollow rod is hung halfway up the window, it seems to bend and then pass directly through the glass. New color illusions and the formation of three-dimensional objects from plain figures will be used to help psychologists find out why we do and see things as we do.

Synthetic Polyelectrolyte

Krilium, the new organic chemical developed by the Monsanto Chemical Company and announced at the Philadelphia meeting of the AAAS, is *not* a new fertilizer, but a soil conditioner, primary effect of which is to increase the percentage of water-stable soil aggregates in clay soils. It does not change soil pH or affect molds and bacteria normally present. Not expected to be commercially available before 1953, the substance is still being studied to determine best methods of application and use in erosion control.

If Winter Comes, . . .

Aphids, those destructive insects that stunt and distort young fruit trees, can be effectively disposed of by the use of dinitro sprays after egg-laying is completed. This means after heavy freezing temperatures have occurred and while the young buds are still in a dormant state. All such sprays are injurious to growing tissues. The various dinitro compounds, although differing in chemical composition and formulation, should be diluted so that each 100 gallons of mixture contains 8-10 ounces of active ingredient.

Can Spring Be Far Behind?

The new chemical spray EH-1, or Crag Herbicide-1, a close relative of 2,4-D, should be applied on clean strawberry beds after the plants are set, acting as a pre-emergence herbicide on grasses and other weeds. In Bureau of Plant Industry tests, the first application was made about five weeks after the berry plants were set, which kept the weeds under control for six weeks. After cultivation a second application was made in July, which controlled the weeds until early winter. The new herbicide will be available to home and commercial gardeners for the 1952 season.

Heating Tape

A flexible heating tape, available in three standard lengths—2′, 4′, and 6′, with respective wattages of 115, 190, and 275—may be used with small glass vessels of either standard or odd shape, such as distillation and fractionation columns. Being well below the glow point, the tape eliminates the danger of fire in the presence of inflammables.

Address a post card to Science and Technology, 1515 Massachusetts Ave., N.W., Washington 5, D. C., for further information about any item on pages iv and v.

THE SCIENTIFIC MONTHLY

FEBRUARY 1952

Rich Man, Poor Man

RALPH F. WOLF

Mr. Wolf (B.S., Catholic University, 1932), who was chief of the Synthetic Rubber Allocation Section of the War Production Board, is the author of many articles and books about rubber. The article below is part of a book manuscript, tentatively entitled "Home Stretch, the Story of Synthetic Rubber," on which he is working at present. In March 1948 The Scientific Monthly *published another section of the book under the title "Eighty-Eight Years of Synthetic Rubber." Mr. Wolf is manager of compounding research at the Barberton (Ohio) laboratories of The Columbia-Southern Chemical Corporation and consultant for the Rubber Division of the Defense Production Administration.*

THE little boy from Hansboeke, Belgium, looked up the long, tree-lined dirt driveway that led to what he thought could only be a great castle. The building bore a name he could understand in the welter of strange-sounding words that flowed past his small Flemish ears—*Notre Dame*—'Our Lady.' In the Belgian village he had left in 1880, now already grown dim in his childish memory, there had been but one *Père*. Here must be all the priests in the world; never before had he seen so many. He could not know, of course, that one day he himself would enter the gates of the University of Notre Dame as a student and, later, become one of the black-robed brotherhood.

The little boy was Julius Arthur Nieuwland, and he was destined to become the most famous man who ever studied or taught at the school the Holy Cross fathers had built in the north Indiana countryside. He and another were to be the men who would give the world its first practical and widely useful synthetic rubber, neoprene. The other was Wallace Hume Carothers, an equally brilliant chemist but a tragic figure who was to die by his own hand at forty-one. An oddly assorted pair—this priest and this suicide. One was a rich, the other a poor, man. The story of the priest will be told first because it was he who set the feet of the other on the path that led to synthetic rubber.

"Neoprene" is the trade name which the E. I. du Pont Company has given to its chloroprene rubbers, first of which was discovered by these men. It is not synthetic rubber at all if one insists upon an exact chemical duplication of natural rubber before bestowing the title. Neoprene contains 40 per cent chlorine in its molecule, an element completely foreign to the natural rubber tree, *Hevea brasiliensis*, and its milky juice. If performance be the measuring stick, then neoprene is truly synthetic rubber, because it does most jobs just as well as the tree gum. Some it does far better.

There were earlier "synthetic rubbers" than neoprene. In 1860, in fact, an Englishman, Greville Williams, made a water-white liquid, which he called isoprene, by destructively distilling rubber, and then turned around and "ozonized" his isoprene into a sort of spongy mass. In 1879 Frenchman Gustave Bouchardat claimed he made rubber by heating isoprene (again obtained from rubber itself) with hydrochloric acid in sealed tubes. In 1884 William Tilden, chemistry professor at Mason College, Birmingham, found he could make isoprene from turpentine. He bottled a considerable

quantity of the liquid and set it aside in a laboratory cupboard. Some gafferish trait in Tilden's character made him save those bottles, and eight years later he found lumps of a yellowish, rubberlike stuff floating in the liquid. There were still other "discoverers": the Russians Kondakov and Lebedev; Fritz Hofmann, Carl Coutelle, and Karl Harries, of Germany's Bayer firm; Francis Matthews in England. During the first of the world wars, Germany actually made about 2,300 tons of highly unsatisfactory, better-than-nothing synthetic. But not until neoprene came along had anyone produced a synthetic rubber that was a really practical material from the standpoint of cost and quality.

In the year 1880, then, Gustave Bouchardat, the Frenchman, was already pointing with pride to his synthesis of rubber; William Tilden, the English chemistry teacher, was peering into his test tubes and pondering how he could make isoprene, supposedly the only thing needed to make the manufacture of rubber a reality; and in a little house in the flat Indiana country, close to the gates of Notre Dame, played a two-year-old Belgian baby. In this year, papa and mama Nieuwland and baby Julius, who had been born February 14, 1878, had come to the United States and settled in South Bend.

Bouchardat and Tilden may have had a long head start on the little immigrant from Hansboeke, but it did not matter. He was destined to help do what they failed to accomplish. Forty years later, in the middle of a life devoted to chemistry and the church, he pointed the way to the creation of the first artificial rubber that was the equal, or even the superior, of *Hevea*, and the first that was a commercial success.

When Nieuwland graduated from Notre Dame in 1899, he had had but little contact with the smells of the chemical laboratory. He had taken the arts and letters course which, in that day, meant four years of Latin and the same of Greek. Botany and biology had been his principal interests, drawing and writing minor hobbies. He designed many of the program covers for school events. In his senior year he wrote an essay on John Keats in competition for the English essay prize, and the school thought well enough of it to have it printed as a university publication.

Nor did Nieuwland have chemistry in mind when his order sent him to Washington to do his graduate work at The Catholic University of America. Two incidents that happened there determined his future. It had been his intention in the first place to major in botany under Edward Green. When Green left the school to take up special work for the Smithsonian Institution, Nieuwland decided to make chemistry his major subject. His professor, John Griffin, was interested in two things. One was the study of the products that can be condensed from acetone, the other was the study of acetylene. Nieuwland needed to give only one awed glance at the formidable equations and formulas involved in the acetone work to make his second important decision—he decided to devote his attention to acetylene. After all, it had a simple enough formula—C_2H_2; but the young chemist soon learned that a complex character lurked behind the simple exterior. Even though he spent nearly forty years in the study of acetylene, he voiced regret shortly before his death that he could not live long enough to complete all the work outlined in his mind.

The thesis Nieuwland wrote for his doctorate at Catholic University was entitled simply "Some Reactions of Acetylene." It is of historical interest for one reason. In it he mentions that acetylene will not react with arsenic trichloride in the absence of moisture or a catalyst, but that it does react in the presence of aluminum chloride. He observed that the reaction product was extremely poisonous and for that reason he apparently did not try to identify it. Fourteen years later, Captain W. Lee Lewis, of the Chemical Warfare Service, stationed at the same laboratory, and engaged in a hunt for the most deadly substances he could find, investigated Nieuwland's reaction further. He identified the poisonous constituent as divinylchloroarsine and worked out the best process for making it. Promptly named "Lewisite" by a public unable to cope with the chemical title, it was reputed to be the most deadly war gas ever made. Its claim to this doubtful distinction has not yet been proved. The first world war ended before the new destroyer reached the front, and gas was not employed in the second.

After having been ordained in 1903 and granted his doctorate in 1904, Nieuwland returned to Notre Dame to take up the teaching of botany and chemistry and to continue his experiments with acetylene. In 1906 the inquisitive chemist passed the gas into a solution of the chlorides of copper and the alkali metals, sodium and potassium. A reaction occurred, but no solid or liquid appeared, so it was assumed that the product was a gas, particularly since a peculiar, powerful odor was produced. For fourteen years he continued from time to time to return to this particular reaction. In 1920 he hit upon the conditions that greatly increased the rate and extent of the acetylene absorption. Once found, the answer proved quite simple. By substituting ammonium chloride for the

alkali metal chlorides, he was able greatly to increase the concentration of his copper catalyst. By altering the acidity of the mixture he speeded up the absorption of the gas. Under the new conditions he obtained, to his great astonishment, a yellowish oil in addition to the gas he had noted so long before.

By methods intelligible only to chemists, Nieuwland proved a year later that the yellow oil was divinyl acetylene, a polymer of acetylene. This means simply that the two compounds contained carbon and hydrogen atoms in exactly the same ratio, but the former molecule was made by linking several of the latter together. Acetylene itself consists of two atoms of hydrogen and two of carbon. The yellow oil was found to have six carbon building blocks and six hydrogens—three acetylenes had joined hands.

Acetylene's new relative was found to be an extremely unstable and dangerous individual. Just left to itself, it would thicken rapidly into a jelly and then into a hard resin, which would blow up without any encouragement. Nieuwland continued to experiment with it, however, and, as he reported: "Our interest was further stimulated in 1923 when treatment of divinyl acetylene with sulphur dichloride produced an elastic substance resembling natural rubber, though too plastic for practical use."

Until 1925 Nieuwland and the Du Pont Company were mutually ignorant of each other's activities. The priest did not know that the big chemical company had been trying to make rubber out of his beloved acetylene. Du Pont knew, of course, that this twentieth-century Roger Bacon was working on acetylene—after all, he worked on little else—but had no idea that he had succeeded in making rubbery materials out of it. Du Pont's chemists had been led to the choice of acetylene as a synthetic rubber raw material for the same reason the Germans had chosen it during the first world war. The gas can be made from calcium carbide, which is made from coal and limestone, two raw materials this country possesses in unlimited quantities. Theoretically, use of acetylene appeared logical; practically, it had not worked out at all. As one Du Pont official has understated it: "We were engaged in research looking toward the production from acetylene of a synthetic rubber that would excel natural rubber in certain respects, but our results had been most disappointing."

In September 1925, the American Chemical Society held its first organic chemistry symposium at Rochester, New York. Dr. Nieuwland was on the program and, naturally, was lecturing on the reactions of acetylene. He was not even casually interested in synthetic rubber—probably nothing was further from his thoughts. But Elmer K. Bolton, a Du Pont chemist who later became director of the Chemical Department of the company, was sitting in the audience and thinking of little else, because he had been working on the problem for some months and had got nowhere with it. Nieuwland told about the yellow oil—divinylacetylene—which he had made from acetylene and mentioned the strange odor that led him to suspect the presence of di's little brother, monovinylacetylene.

Bolton followed the discussion intently and lost no time after the meeting in telling Nieuwland about the troubles the Du Pont laboratory had encountered. Out of this chance meeting came an agreement between the university and the industrial firm regarding royalties, and a group of Du Pont men visited the South Bend campus to learn about divinylacetylene from the master of acetylene himself.

Yes, royalty arrangements were made. Did Nieuwland, then, become a fabulously rich man as a result of his discovery? No, he never made a single penny from his work! Before the reader's indignation rises over such seeming injustice it should hastily be explained that the patents were assigned exactly as Nieuwland wanted them. He had taken a vow of poverty when he entered the religious order of which he was a member—the Congregation of the Holy Cross—and his royalties were paid directly into the coffers of the order. Over the course of years this has meant many thousands of dollars for the order's school, Notre Dame. It was irony compounded that, when the clue to the synthetic rubber riddle was finally found, it was discovered by a man who not only was not looking for rubber but who also cared nothing about making a fortune.

Although Nieuwland's discovery sounds simple in the telling, its importance should not be underestimated. The Du Pont Company certainly did not underestimate it. Its spokesmen have credited his discovery with being "the essential first step" and "the key to the synthetic rubber problem." The yellow oil never yielded a satisfactory synthetic rubber. Normally it tends to turn into a resinous rather than a rubbery product. Although means were found to prevent this, the resulting material was never very good. Every batch varied, and none retained its elasticity for the same length of time.

Meanwhile, the gas of the powerful odor which Nieuwland had noted as early as 1906 was being investigated at Du Pont's experimental station. As he had suspected, it proved to be monovinyl-

acetylene when it was finally trapped by W. S. Calcott, F. D. Downing, and A. S. Carter. Chemists have a passion for purity, at least in the new chemical compounds they discover, and experimenter Arnold Collins tried separating the monovinylacetylene into different fractions. Luckily, this was the last thing he did one week. The different "cuts" stood over the week end and by Monday morning one had solidified. Presence of an impurity was suspected, and analysis revealed it to be chlorine. Carothers, leader of the group, suggested that hydrogen chloride be added deliberately to the monovinylacetylene. This was done, and a thin, clear liquid resulted. In such manner, from the wedding of two gases, was chloroprene born.

The name chloroprene sounds like isoprene and for good reason. Prevail on a chemist friend to draw a picture of the two materials, and you will need to look closely to discover the difference. Finally you will see that chloroprene has an atom of chlorine hanging from one of its carbon atoms and isoprene has a methyl group, like this:

$$\begin{array}{c} H_2C{=}C{-}C{=}CH_2 \\ \;\;/\;\;\;/ \\ Cl\;\;H \end{array}$$

CHLOROPRENE

$$\begin{array}{c} H_2C{=}C{-}C{=}CH_2 \\ \;\;/\;\;\;/ \\ CH_3\;\;H \end{array}$$

ISOPRENE

However slight the difference on paper, the presence of that one chlorine atom actually makes a tremendous difference in the two materials, for chloroprene will polymerize into a rubberlike solid seven hundred times as fast as will isoprene. When chloroprene molecules polymerize—or grab their neighbor's hands—they become neoprene. In commercial practice the polymerization is stopped at an intermediate stage, and a material similar to soft, unvulcanized rubber is obtained. This is sold to manufacturers, who mix various fillers into it in the same way that they compound rubber and then vulcanize it by further heating. Neoprene does not require the addition of sulfur for vulcanization, differing from rubber in this respect. After heating, it is similar to fully vulcanized rubber obtained by heating natural rubber with sulfur.

It has been mentioned that neoprene actually should not be called a synthetic rubber because it has chlorine in its molecule and natural rubber has none. Identical or not, it was the first practical material ever made that would do all that natural rubber would do, just as well or even better. Unlike the synthetic rubbers that preceded it, neoprene has its uses in peace as well as in war. Compared to natural rubber it is much more resistant to oils, solvents, and many chemicals; it is more resistant to aging caused by air and light; it is less easily permeated by gases.

The world first heard about chloroprene synthetic rubber at a meeting of rubber chemists held in Akron, Ohio, on November 2, 1931. The research men in the audience were keenly interested, the "practical" men only mildly so. The latter foresaw little market for a synthetic rubber the price of which was estimated at \$1.00 a pound at a time when the best grade of *Hevea* smoked sheets was selling at 4½ cents. The initial commercial production of DuPrene, as it was then called, started in 1932, and the price was \$1.05 a pound. Even at that figure, it was so much better than natural rubber for oil and gasoline hose, rubber mountings for automobile engines, oil-well parts, printing rolls, and all sorts of things such as gaskets, packing, and belts that had to stand up against oil and grease that it found a waiting market. This market was small at first but grew steadily, and production doubled in every year from 1932 to 1940, except for 1938.

In 1935 a plant capable of producing 500 tons a year was completed, and this enabled Du Pont to drop the price to 75 cents a pound in April 1936. By 1941 use of neoprene had increased to about 6,000 tons a year, and the price had dropped to 65 cents.

As part of the wartime synthetic rubber program, the government built facilities for the annual production of 40,000 tons of neoprene in addition to the 10,000 Du Pont could then produce privately. It might well be asked why neoprene drew so small a proportion of the 900,000-ton total of synthetic rubber which the government planned to make. It was the first generally useful synthetic and it was the one with which the rubber goods-manufacturing industry had the most experience. It was described by the Baruch Rubber Survey Committee as "the one synthetic rubber which has been shown to be the full equivalent in quality of natural rubber for combat and heavy duty tires." The answer is that great quantities of electric power are required to make the calcium carbide which makes the acetylene gas from which the neoprene itself is made. Electric power was scarce in the war days, as those who remember the "brown-outs" can testify. Peak consumption of neoprene was reached in 1944 when 46,243 tons were used. By 1949 usage had fallen back to 31,753 tons, but then as a result of emergency conditions it jumped back up to 43,781 in 1950 and came close to touching 50,000 tons in 1951.

Although Nieuwland was not actively connected with the synthetic rubber problem after the early thirties, he maintained his interest in it to the last. In foresight, at least, he yielded to no one. In accepting the Nichols' Medal in 1935 he stated that DuPrene was by no means the last word in synthetic rubbers, and that we would see a score of similar substituted rubbers within a decade. "It is not improbable," he said, "that the not far distant future will present us not only with cheaper and better, but even with innumerable, substituted diene rubbers. The synthetic medicinals and dyes have replaced the natural, why should not the synthetic rubbers?" This was a bold prophecy to make at a time when usage of synthetic rubber was insignificant. The fact that it came true is a good indication of the prescience of the prophet.

Rubber was not the only field in which Nieuwland expected the chemist to make startling advances, and he was equally generous—and correct—in some of the predictions he made. At the time, little was known about catalysts. Many chemicals will not react together until brought into the presence of a third substance—the catalyst—which, remaining unchanged itself, causes the first two to unite. A catalyst is a middleman, a sort of marriage broker for the nuptials of chemicals A and B. It was in this field that Father Acetylene looked for great advances. The plant was his ideal chemist for, as he liked to point out, it could take a pail of water and a little carbon dioxide and turn them into a bushel of potatoes. His comments on the subject are highly interesting and are repeated here even though not too pertinent to the present story:

It is surprising how easily men of science persist in overlooking the simply obvious [Nieuwland said]. Chemists have for some time felt that future progress of science depends upon the discovery of new catalysts. Probably the idea that reactions in the vapor phase at high temperature must be used with catalysts is too much overemphasized. Plants and animals synthesize substances at moderate temperatures. There is no reason why the laboratories or the industries should not do likewise. The great difficulty consists in finding substances that are efficient catalysts. Little is known about the nature of catalysts, and we are still wasting too much time in disputing the definition of something we know imperfectly. Since few or no consistent standards of selecting catalysts are available, it seems that for quite a long time we shall have to select them empirically. Nevertheless, we may assure ourselves that the synthetic chemistry of the next two generations will be largely catalytic. The all-important vegetable plant which with a minimum of energy produces substances in ways we cannot now imitate, will undoubtedly in the future be replaced by an industrial plant which will with a machine catalytically take in simple products and, without loss of time and motion and without the aid of extreme heat, discharge the complex substances we desire. . . .

Father Nieuwland died June 11, 1936, while on his annual vacation at the Holy Cross house of studies on the Catholic University campus in Washington, D. C. The manner of his passing was particularly appropriate. While visiting friends in the laboratory where he had first met his life's love, acetylene, his heart simply stopped beating. So passed a man whose life had been a completely happy experience. Rich man? Poor man?

Unlike many specialists who lose all interest in everything but their specialty and live progressively narrower lives, Nieuwland never lost his appreciation of the things that appeal to the imagination and stir the emotions. To his last day he maintained his interest in literature, drama, and music. Nor did he lose the common touch. Along with literature, he liked detective thrillers and occasionally retired to a quiet corner of the Notre Dame science building, stoked up a foul pipe, and spent an afternoon with Poirot, Philo Vance, and Father Brown in complete forgetfulness of test tubes and beakers. Along with his appreciation of the best in music, he kept up his undergraduate ability to play a guitar, but when urged by a colleague to play over the university broadcasting system he defined a gentleman as a man who can play the saxophone and doesn't. Along with good poetry he took great delight in collecting limericks and nonsense verse, particularly those that had a scientific angle, such as the amusing lines concerning the dinosaur who, with a brain in both head and tail, could reason *a priori* and also *a posteriori*. Along with the drama, he enjoyed the movies and was a regular Saturday night attendant at the university theater. Every circus that hit South Bend found Nieuwland in attendance with a couple of youngsters tagging at his heels.

His botany always held a definite, although minor, place in his affections. Occasionally, he would leave his chemistry for a botanical excursion, and he also borrowed time to found and edit, until 1931, *The American Midland Naturalist;* to act as curator of the Edward Green Herbarium; and to found the Nieuwland Herbarium at Notre Dame. His love for chemistry was always dominant, however, and the great benefit of his excursions away from it was that they sent him back refreshed and ready for more labor in the laboratory, where he frequently ate his meals and often stretched out for a few hours of sleep on a worktable, with an apron for a pillow. The doors of his laboratory, incidentally, were equipped with foot treadles so that he could open them without setting down the beakers or other vessels with which his hands were always occupied.

Up to this point, only brief mention has been made of Wallace Carothers. His name is virtually unknown to any but chemists, but by them he is regarded as one of the immortals. Carothers took Nieuwland's discoveries in the field of acetylene and turned them into a synthetic rubber on which Du Pont has built an important and highly profitable business. This was not his only accomplishment of great industrial importance. Everyone knows about nylon and what a strong, beautiful material it is. Taken for granted now, no one stops to wonder where it came from or who first thought of it. Where *did* it come from? Out of the brilliant mind of Carothers, who conceived the idea of making synthetic materials of all sorts from gigantic molecules and then proceeded logically step by step to prove his theory, creating nylon as the final and inevitable proof.

An article such as this can add little to and detract nothing from Carother's fame. The thing it can do is make the lay reader wonder if there are not other unsung scientists who never receive just credit for their exploits. There are and there probably always will be. In the past two and a half decades it has become increasingly the style for manufacturers to foster the idea that new developments are the work of teams of researchers and that it is impossible to single out individuals for the award of praise or wealth. It is usually true that many minds will be called on for ideas before a new thing is developed to the point where it can be put into regular production. It is equally true that the basic idea that made it necessary to set all these other minds in motion had to originate in some one single brain. But individuals are seldom mentioned in the millions of dollars worth of oral and visual advertising that constantly assaults our ears and eyes. It might make such men too much aware of their true value.

So it is that some nonchemists know about Nieuwland, a scholastic; none about Carothers, an industrial man.

Wallace Hume Carothers was born in Burlington, Iowa, April 27, 1896. Forty-one years and two days later he died in Wilmington, Delaware, after drinking cyanide dissolved in lemon juice. Into a relatively few productive years he crowded more creative work than most chemists would accomplish in several lifetimes.

When Wallace was five, his family moved to Des Moines, where his father taught in the Capital City Commercial College. After finishing high school, the boy whipped through the accounting and secretarial courses of the business college in less than a year and in 1915 enrolled in the scientific course at Tarkio College, Tarkio, Missouri, thereby ensuring its fame for all time. His interest in the sciences was so great that he quickly outdistanced his classmates and within two years had completed all the chemistry courses the school offered, even though he was acting as an assistant in the commercial department at the same time. With the coming of the war Arthur Pardee, head of the chemistry department, left to go to another school. The little Missouri college was unable to find another qualified teacher, so the gifted Wallace took over the job. A testimony to his ability is the fact that later the four members of his class who majored in chemistry all made names for themselves in that science.

Carothers left Tarkio in 1920 for a year of advanced study at the University of Illinois and then went to the University of South Dakota to teach analytical and physical chemistry. With funds replenished, he headed back to Illinois in 1922 to complete his studies under the direction of Roger Adams. While still a student he published a classic paper on the double bond which, in essence, contains everything since written on the subject. When he received his degree in 1924 he was considered by the staff to be the most brilliant student ever awarded the doctorate in chemistry by Illinois. In the fall of the year he was appointed an instructor in organic chemistry and for the next two years he taught with outstanding success. In 1926 Harvard University needed an organic instructor, surveyed the field, and chose Carothers. He maintained the same brilliant pace at the Eastern school and, at this time, did his first thinking about polymerization and the structure of high molecular weight substances.

Du Pont, in 1928, decided to embark on a program of fundamental research and set out to find the best man available for the organic chemistry section. Carothers received the highest possible recommendations from both Illinois and Harvard. After considerable soul-searching he decided to give up academic life and accept the Du Pont offer because the position demanded only research and offered a staff of trained men and freedom to work on any problems he chose.

Carothers lived up to all expectations. "One of the most brilliant organic chemists ever employed by the Du Pont Company," was the way Chemical Director Bolton later described him. His reputation continued to spread like a supernova explosion. Not only his own colleagues, but chemists all over the world sought his advice. In 1929 he was made associate editor of the *Journal of the American Chemical Society*, a tremendous honor, it should

be explained, for a thirty-three-year-old. In 1930 he was made an editor of *Organic Syntheses.* Scientific societies of both this country and Europe sought him as a speaker. In 1936 the august National Academy of Sciences broke a long-standing precedent and elected Carothers a member, the first organic chemist associated with industry who ever made the grade.

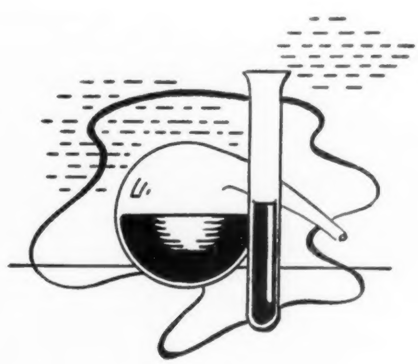
As a boy, Carothers was said to have been strongly under the influence and guidance of his mother. Later, he was much devoted to his younger sister, Isobel, who may be remembered by older readers as Lu of the radio trio Clara, Lu, and Em that had some vogue in the early thirties. Isobel, the wife of Howard Berolzheimer, of the Northwestern University School of Speech, died of pneumonia after a three-day illness, January 8, 1937. Her death, at the age of thirty-one, was a severe shock to which her brother never reconciled himself in the few months remaining to him.

Carothers was a genius beyond dispute. Like many another genius, he was not well balanced. He was a chronic depressive for many years. During his last years the periods of depression grew more and more pronounced in spite of the best medical advice and care and the untiring efforts of friends and associates. In its way, Du Pont did everything it could. Carothers was given the finest medical attention, he was given long rests, he was relieved of responsibilities and his work load lightened. This last may have been the wrong thing to do. It probably would have been better to encourage such a brilliant and restless mind to keep occupied with new and intriguing research problems, so that it always would have had some new thing to wrestle with and would have had no time to concern itself about the shell it occupied.

Seemingly, Carothers had everything to make life desirable and worth living—family, eminent position, tremendous reputation in his profession, work that was itself his life. For the future, he could look forward to many years of research that would have steadily enhanced his name and would have been of inestimable benefit to mankind. Rich man? Poor man?

On the morning of April 29, 1937, Wallace Carothers registered in a Wilmington hotel. He remained in the room all day. In the evening he was found dead, beside his body a few grains of poison crystals, a squeezed lemon. The book that was only well begun was closed forever.

The lives of Nieuwland and Carothers would make a great study for some scientist of the mind. Both were exceptionally brilliant men. One lived a completely happy life, his only complaint that there was so much to do, so little done. The other —mentally at the antipodes—found nothing worth while and time so long it needs must be cut short. Rich man, poor man!



The Mining District of Kiruna Stad, Sweden*

LUCILE CARLSON

Lucile Carlson, who is assistant professor of geography at Western Reserve University, took her Ph.D. at the University of Washington in 1947, where she afterwards taught for a year. She spent the summers of 1949 and 1950 traveling in Europe, part of the time doing special research on the Swedish iron and steel industry. The material appearing here was collected when she visited the mines at Kiruna.

IN NORTHERN Sweden, in the Lappland province of Norrbotten, there are large deposits of some of the richest iron ore in the world. The known reserves are somewhat scattered, but major exploitation of these northern ores is carried on in two places, at Gallivare, near which the Malmberget mines are located, and at Kiruna (Fig. 1).

Kiruna lies about 80 miles north of the Arctic Circle in the midst of Lapp territory. One realizes the latitudinal location (67° 50″) better when it is compared with other areas (Fig. 2). This parallel runs to the north of the Yukon country of Alaska, some three degrees farther poleward than Fairbanks.

Kiruna Stad is, in area, Sweden's—and perhaps the world's—largest "city." It is not a city in the ordinary sense of the word. *Kiruna Stad* means "town of Kiruna," but it occupies a space of some 8,000 square miles. Within this greater Kiruna, beside the Luossavaara-Kirunavaara ore mountains, is located the mine town as we know it, Kiruna proper. The urban center has a population of 12,000 inhabitants; Greater Kiruna has only 6,000–8,000 more people scattered throughout its vast area.

Kiruna is situated along the shore of Lake Luossajarvi at the base of the southwestern slope of the cone-shaped ore mountain Luossavaara (Fig. 3). On the other side of the lake and valley rises Kirunavaara, a mountain the backbone of which consists of a huge concentrated mass of ore. Originally, at its highest point, it rose 820 feet above the lake. As open-pit mining began and continued, the ore was removed in broad benches each nearly 50 feet high (Fig. 4). Now a deep cut, which drops in a series of terraces, runs as a great valley through the entire length of the mountain, opening it at one end to only 16 feet above lake level. The inner terraces are matched on the outer slopes of the mountain by other great steps built up of the gangue and overburden that were removed in the surface mining and dropped along the exterior (Fig. 5). Thus during the fifty years of extraction, Kirunavaara has completely changed its profile, so that today it resembles, in configuration, some of the great terraced mountains of the Orient.

The peak of Luossavaara (Fig. 6), which rises to an elevation of some 700 feet, is still untouched, though one cut occurs near the crest of the mountain, and another, parallel vein, known as Rektorn, midway down the eastern slope.

The Iron Deposits

The great Kirunavaara deposit, including the beds under Lake Luossajarvi, has a length of about 2 miles and a width of up to 650 feet, averaging

* This article is largely based on material gathered directly in the field by the writer. The research was made possible through the help and courtesy of E. Ohman, Jernkontoret, Stockholm, and John Tornqvist, Overengineer for Luossavaara-Kirunavaara Aktiebolag, Kiruna, Sweden. The following source materials were used in collecting or corroborating certain data:

Grängesbergskoncernens Malmfält. Report of Trafik Grängesberg-Oxelosund (1950).

Statistical Bull. British Iron and Steel Federation (October 1947).

OIR Report No. 4260. Washington, D. C.: Div. International and Functional Intelligence, Office of Intelligence, Dept. State (April 30, 1947).

LINDGREN, W. *Mineral Deposits.* New York: McGraw-Hill (1933).

Record books of Luossavaara-Kirunavaara Aktiebolag, Kiruna, Sweden.

FIG. 1. Norrbatten, showing the most important of the known iron ore deposits of northern Sweden. Dots mark locale of hydroelectric plants; dots with arrows indicate ore beds. Also shown is the Ore Railroad that connects the mining districts of Kiruna and Gallivare (Malmberget) with Narvik, Norway, and Luleå, Sweden. (Courtesy Luossavaara-Kirunavaara Aktiebolag, Kiruna.)

about 328 feet (Fig. 7). The depth of the ore body has not been completely determined. Magnetic measurements confirm that the deposits extend deep into the earth, and, although the results cannot be taken as absolute, the depth of the ore bed appears to be between 4,000 and 6,000 feet. In order to obtain more certain estimates, depth drillings have been made to beyond 1,600 feet. The ore area to this level has been found to be, by and large, the same as on the surface, though the quality varies. The deepest drilling, 2,370 feet, has been done beneath the surface of the lake. Assuming a fairly constant quantity of ore to this level (i.e., to the level of depth drilling), it is estimated that there are 1,600 million tons of ore reserves, of which 158 million tons have been mined.

Mining engineers estimate that it will be possible to extract the additional reserves at the deeper levels when the upper layers are exhausted, because techniques should have advanced sufficiently far by that time to permit their economic development.

The Kiruna ores are composed of magnetite with only 5–8 per cent gangue if the apatite, which has value as raw phosphate, is not taken into account. They contain, however, a high content of phosphorus, requiring the Thomas-Gilchrist process for the removal of this element.

There are many combinations of iron and phosphorus, ranging from a high phosphorus content of over 3 per cent down to less than .03 per cent. The Lappland ore tends to follow the rule that as the content of iron increases the phosphorus content decreases, and vice versa. For example, the "A"-ore in the Kiruna deposits with 68 per cent iron has but .02 per cent phosphorus, whereas the dominant type, the so-called KD-ore, contains 60 per cent iron and 2 per cent phosphorus. In this latter type apatite makes up 11 per cent of the ore. In certain parts of the deposit the phosphorus content increases to 3 and 4 per cent and, in the Rektorn vein, averages 4½ per cent phosphorus, with an iron content of only 30–40 per cent. Phosphorus-poor ores dominate in the Luossavaara veins and can also be found in the northern part of the Kirunavaara beds.

Because of the many grades of ore the iron deposits have been mapped in detail. Thousands of

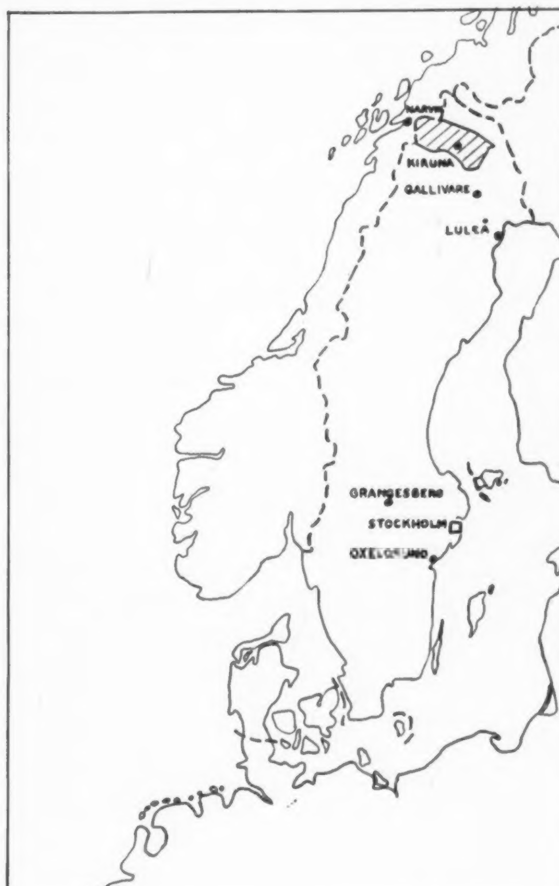


FIG. 2. Location and area of Kiruna Stad in relation to the remainder of the peninsula.

samples are taken from the ore beds, graded as to quality, and the types of ore then plotted on a map, which is followed in the mining. In extraction the different grades of ore are, as much as possible, kept separate. In order to satisfy the large demand for iron-rich and phosphorus-poor ore, this type has been mined heavily; sometimes, undersurface mining for the richer ores precedes the extraction of lower-grade surface ores.

Since practically all the ore comes clean from the mine as first-class lump ore, no concentration is necessary other than to remove the rock that sometimes falls in. Only a crushing process is required before shipment. Unlike some magnetites, the Kiruna ore can be crushed, because of its unmixed character. Two small separation plants have

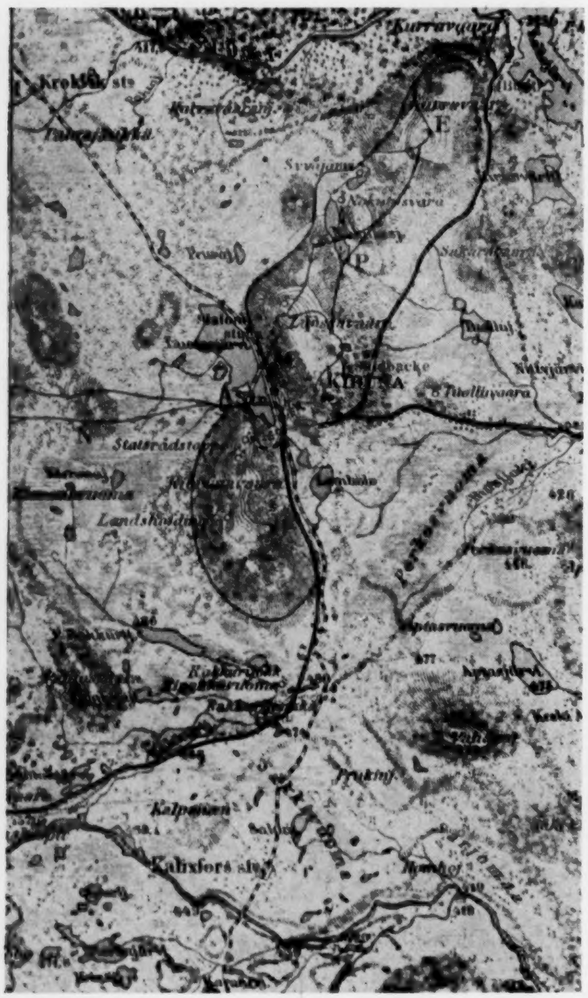


FIG. 3. Detail of the Kiruna mining district. Mount Kirunavaara lies to the southwest of Lake Luossajarvi, and the city and Mount Luossavaara are situated along the eastern shore. Farther to the east is a small ore-bearing mountain, Tulluvaara, privately run and producing small amounts of ore. (Courtesy Swedish State Railways.)

been erected for the ore that has been mixed with gangue. Where concentration is desired, as with the phosphorus-rich Rektorn or, at times, KD-type ores, the mineral is sent to the enriching plant at the Malmberget mines near Gallivare.

Generally, after crushing, the only need is to test the ore. This analysis is completed at the mine while the ore trains are en route to the shipping ports and is telephoned to the harbors, so that on arrival the ore can be directed to ships or storage yards, according to the demand for the particular grade of ore sent from the mines.

Fifty per cent of the output of Luossavaara comes from underground, but on Kirunavaara 95 per cent of the ore is still taken by open-pit methods. As the surface mining has gone on and the depth of the pit has become greater, larger sections of the mountainside had to be taken away, with a decrease in the proportion of ore relative to the total amount of material dug. From almost 100 per cent ore in the beginning, the proportion has decreased to 55 per cent.

Removal of the rock material has been continued during periods of low ore demand. This has made the labor requirements more stable, and the expense of the periods of low ore market has been returned in times of high demand.

Surface mining has continued below the level where it was at first thought advantageous to change over to underearth mining. The plan now is to continue surface mining all the way down to the railroad, which lies at lake level. The next four years will see an increase in shaft mining on Kirunavaara, however, and, within a ten- to twenty-year period, all digging will be done below the surface (Fig. 8). Preparations for undersurface mining have already been begun. In the main the mining method will be that of "block-caving" within the KD-ore areas, but some selective mining will be necessary so that the different grades of ore can be kept separate.

In taking the ore from the open pit a number of holes, 1 foot in diameter, are driven into the ore bed along the edge of the terrace. They are drilled approximately 16 feet apart, the depth being adjusted to the height of the terrace. After a series of ten to twenty holes has been drilled, they are loaded with dynamite or other explosives, amounting in total to $1\frac{1}{2}$–$3\frac{1}{2}$ tons. The explosives are then discharged electrically by remote control. One blast loosens 25,000–30,000 tons of ore—one day's digging.

The ore is loaded by means of electric shovels into tip-wagons and carried to the crusher, where huge steel jaws break the magnetite in a matter of

Fig. 4. View from the Kiruna side of the valley, near picturesque church of Lapp design, shows clearly the huge cut that now exists on Kirunavaara. (Courtesy LKAB.)

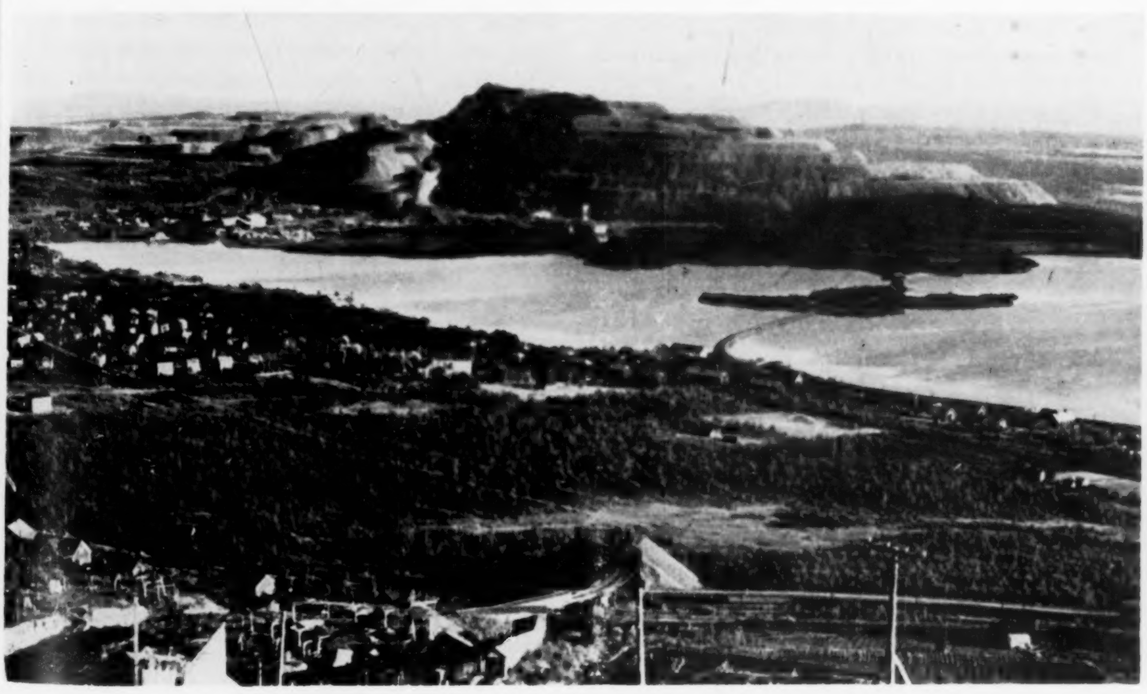


Fig. 5. Mount Kirunavaara and the southern end of Lake Luossajarvi. Notice that railroad crosses the lake instead of going around it. (Courtesy LKAB.)

seconds. From the crusher the ore drops through vertical shafts to the so-called lake tunnel, where the iron is loaded directly into railroad cars for immediate transportation to Narvik, Norway, or Luleå, Sweden, on the Gulf of Bothnia.

Mining goes on all winter, production varying little from month to month. Work is therefore not seasonal. During the dark portion of the winter the surface mines and the terraces of the mountains are illuminated by electric lights night and day. Power is generated at Porjus, 73 miles away, and transmitted over a 70,000-volt lead to the Kiruna power plant, where it is converted by single-phase transformers to about 2,200 volts.

Although winter temperatures are low and snow cover is heavy, these conditions have astonishingly little effect on the mining (Table 1). During the months in which the most severe winter conditions obtain (i.e., January–March), production amounts to at least 85 per cent of the highest summer output.

The cost of removing the mass of snow is considerable. Under usual conditions, snowplows are used, but when these are not adequate, tractors with bulldozers are employed. Rotary snowplows are not expedient because snow frequently mixes with the rock during blasting. In certain places, where wind forces the snow against critical areas, snow fences are put in to control the drifting and piling of snow if operations permit.

As a consequence of the snow mixing with the ore to a certain extent, while being transported to the shipping points the ore often becomes frozen into a single great lump in each of the railroad cars. In order to remove the mineral from the cars, therefore, special methods must be used, such as heating by steam, employing shakers, etc.

FIG. 6. Mount Luossavaara as seen from the pit of Kirunavaara. The two cuts of Luossavaara, one near the crest and the other down the slope (Rektorn), may also be distinguished. (Courtesy LKAB.)

The annual production during the past fifty years has shown a continuous, though irregular, increase. The graph (Fig. 9) confirms this. At present, 25,000–30,000 tons of ore approximate one day's digging. Eighteen trainloads per day move from the mines at Kiruna to the ice-free ports of Narvik and Luleå.

Luleå and Narvik do not compete with each other for the shipment of iron; in fact, they are reciprocal through agreements worked out between the State Railway of Norway and Sweden and the mining company (Fig. 10). All the Kiruna ore goes out through Narvik except two trainloads daily, which are sent through Luleå, whereas the Gallivare ore is shipped through Luleå except for two daily trainloads, which go to Narvik.

Swedish government regulations determine the amount of ore shipped from each mine. Therefore, if either Kiruna or Gallivare increases the number

TABLE 1

TEMPERATURE AND SNOW CONDITIONS AT KIRUNA, SWEDEN, DURING THE WINTER MONTHS OF 1950–51

	JANUARY	FEBRUARY	MARCH	APRIL*	OCTOBER	NOVEMBER	DECEMBER
1950							
Minimum temperature (°C)	–37.3	–28.7	–29.2	–18.0	–8.5	–25.3	–28.7
Average temperature (°C)	–15.0	–12.8	– 7.5	– 1.3	+0.6	– 8.7	–11.2
Depth of snow (in.)	22.8	23.6	25.6	37.8	—	11.8	18.9
Maximum precipitation per day (in.)	0.2–	0.24	0.2–	0.54	0.2–	0.34–	0.2–
1951							
Minimum temperature (°C)	–28.7	–30.3	–27.0				
Average temperature (°C)	–16.2	–13.2	–11.4				
Depth of snow (in.)	23.2	25.6	26.7				
Maximum precipitation per day (in.)	0.2–	0.2–	0.26				

* It is perhaps significant to note the increasing build-up of the snow cover to a maximum depth in April. (In the last 10-year period the maximum monthly precipitation, totaling 5.7 inches, occurred in October 1942). Quotations from John Tornqvist, Over-engineer, Luossavaara-Kirunavaara Aktiebolag.

of trainloads of ore to either port (thereby reciprocally decreasing the quantity shipped to the other), the deficiency at the latter port must be made up by increased shipments from the other producing area. Contrary to what is generally supposed, Narvik does not act as an alternative port for Luleå, even during the winter months when the Baltic is frozen over. Shipments from both mines continue the year around to both ports, and when not immediately sent abroad, the ore is stored near the docks. Nine million tons of ore were permitted to be exported from the Lappland mines in 1949, more than two thirds of this from Kiruna. Provisionally, an annual increase in export of 2 million tons of ore from the Lappland fields is expected.

Production and Export

The foundation for the export of Lappland iron was laid when, about the turn of the century, a single-tracked railroad was constructed connecting the mines at Kiruna and Gallivare with Luleå and Narvik. The distance to Narvik along the "ore railroad," as the railway line is called, is about 90 miles, 72 on the Swedish side, 18 on the Norwegian; that from Kiruna to Luleå, 186 miles.

In neither direction is the transportation of ore made difficult by extreme grade (Fig. 11). The greatest rise which the loaded trains have to pass occurs between Lake Tornetrask and the Swedish-Norwegian border, an ascent of about 21 feet per mile. Though the slope on the Norwegian side is greater, averaging 70 feet per mile, this steep grade is climbed when the cars of the ore train are empty; therefore it is accomplished without great difficulty because of the powerful engines used. The line is electrified throughout.

No automobile roads lead toward Narvik. The sole means of transportation between Kiruna, the

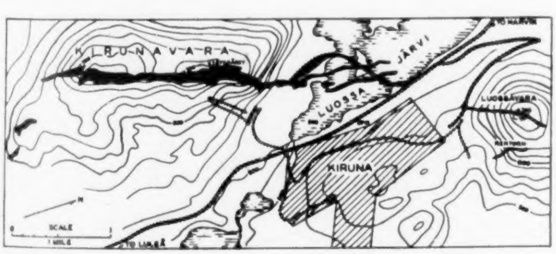


Fig. 7. The Kiruna ore beds are found spread over a distance of more than 4 miles in a series of plates, or lenses, between two porphyry beds. The main ore body, that of Kirunavaara, which originally came to the surface along the crest of the mountain, continues in two separate lenses to the south, and also to the north under the lake. Half a mile farther north, the ore body reappears as the deposits of Luossavaara. (Courtesy LKAB.)

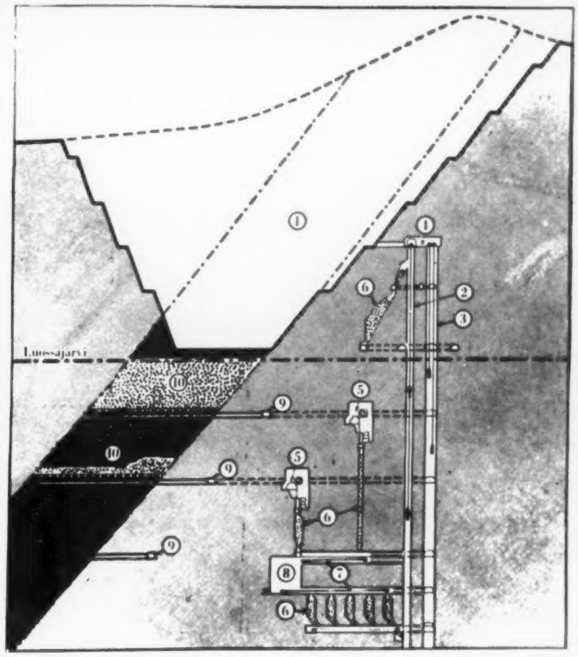


Fig. 8. Cross section of the planned undersurface mining. As the present railroad tunnel is located in ore and consequently will be damaged when the surface mining reaches this level, new transportation tunnels have been constructed in the side wall, two for ore transportation and another for moving people. Four or five shaft groups will be put in, each group having one shaft for people and one stone shaft with a lifting capacity of about 2 million tons annually. 1, part of the surface mine where the ore has already been removed; 2, stone shaft; 3, shaft for the transportation of people; 4, hoist room; 5, crushing plant; 6, ore pockets; 7, transport band; 8, concentration plant; 9, horizontal shafts running into the ore veins; 10, ore magazine. (Courtesy LKAB.)

Swedish border to the west, and the farther Norwegian port is the railroad. There is only one highway leading out of Kiruna. This is a graveled road that extends southward, connecting Kiruna and Gallivare. No new highways are being built or planned.

The Kiruna and Gallivare mines are owned by Luossavaara-Kirunavaara Aktiebolag, which also owns the port facilities at Luleå and Narvik. Half the stock of this company belongs to the Swedish government, and the other half to a private corporation, Trafik Grängesberg-Oxelosund. Under the original agreement between the private concern and the government, the state had the right to purchase the shares of the private company in September 1932. The option was not used, however, and the time limit has been extended several times, at present to 1957. The contract can be renewed every ten years if the "right to redeem" is not used.

Most of the ore is exported, for Swedish industry cannot economically use the high-phosphorus ore. Domestic iron and steel production is based almost

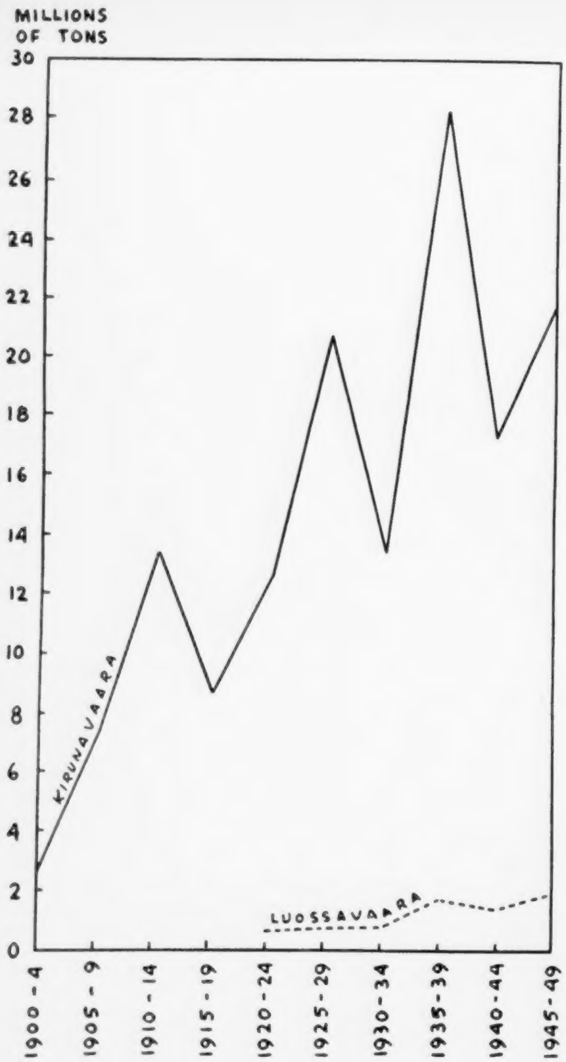


FIG. 9. Ore production in five-year periods. Upper line indicates Kirunavaara production, lower, Luossavaara production. Before 1900 less than 5,000 tons of ore were taken from the Kirunavaara deposit; before 1920 only 216 tons were mined on Luossavaara. (From the production record book of LKAB at Kiruna.)

entirely on the low-phosphorus but fairly high-sulfur content ores of central Sweden. Only 100,-000–200,000 tons of Lappland ore a year are taken for domestic use. This use will increase, however, because of the establishment of a government-owned iron works at Luleå—Norrbottens Jarnverk Aktiebolag—begun in 1942 and expanding rather rapidly. Its iron and steel production will be based entirely on Lappland ore.

Before the war the biggest customers for Kiruna ore were England and Germany. Since the war, however, Belgium leads, taking 30 per cent. The United States and England rank second, taking approximately 20 per cent each, Germany third, and then Holland.

Sweden is estimated to have 2,200 million tons of iron ore, or about 7 per cent of the world's know "actual" reserves. Of this, 80 per cent is located in Lappland, 64 per cent of Sweden's total in the Kiruna district itself.

If the given figures are reliable, then these Swedish ore beds are larger than any found within the Soviet Union, those of Krivio Rog, the greatest producing mines of the USSR, containing actual reserves of only 668 million tons; of the Kerch Peninsula, with the largest reserves, 1,500 million; and of Magnitogorsk but 400 million.

The United States has no single deposits of proved ore beds as large as those of Kiruna. The reserves of the famous mines, those of the Mesabi Range in northern Minnesota, now stand at 992.6 million tons, and the poorer-grade ores of Alabama are quoted at 1,522.6 million tons. The United States and the USSR each have approximately

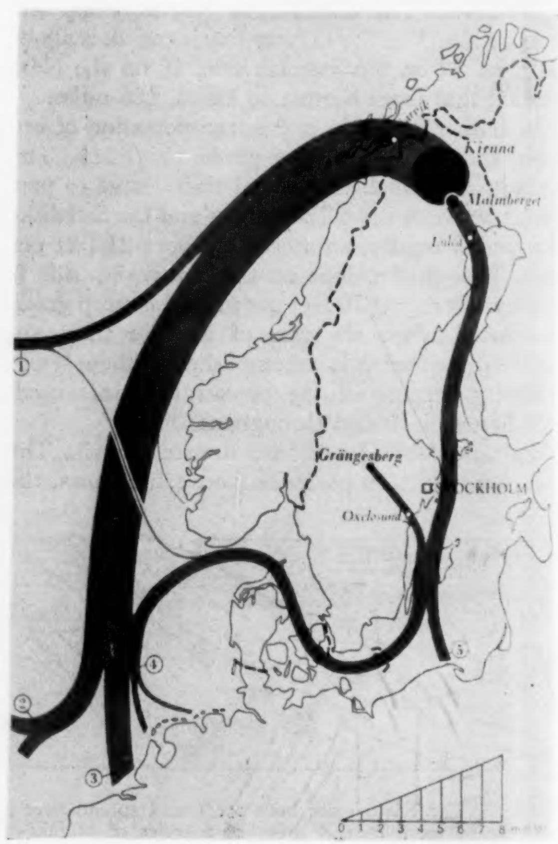


FIG. 10. Map showing flow of ore from the Lappland mines through the ports of Luleå, Sweden, and Narvik, Norway. About three and one-half times more ore moves through the Norwegian port than through Luleå. (Courtesy LKAB.)

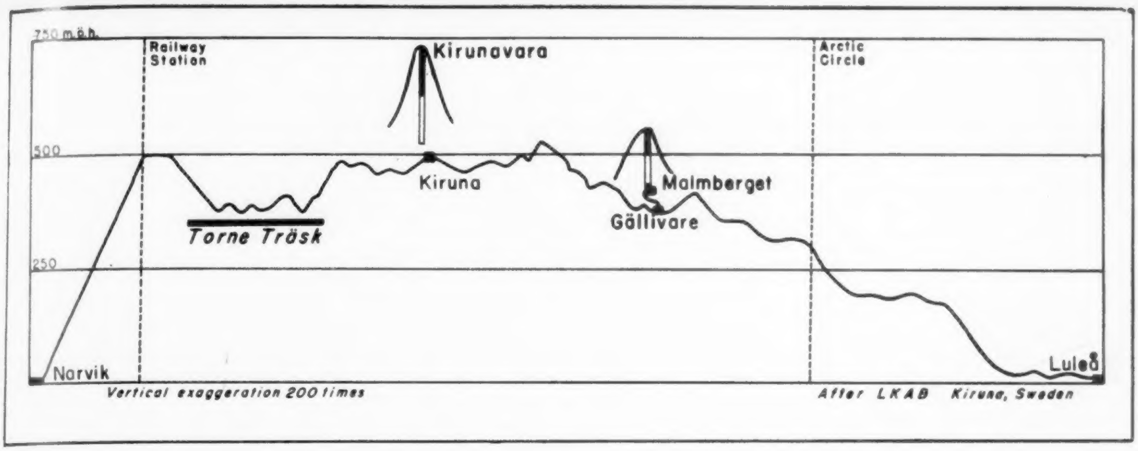


FIG. 11. Profile of the Ore Railroad with the peaks of Mounts Kirunavaara and Malmberget beside it for comparison. Solid portion of the vertical shafts indicates depth to which mining has taken place. (Courtesy LKAB.)

11 per cent of the world's proved reserves of iron ore.

There are only two known deposits in the world that have actual proved reserves of iron ore greater than Kiruna—the Minas Geraes and the Lorraine ores. In neither of these larger deposits, however, does the percentage of iron content average as high as at Kiruna.

Kiruna is ore and ore only. Yet it is not a boom town. It is a compact and planned community. The solidity of the construction of its houses, stores, and public buildings, the paved streets and boulevards (with tracks for the electrically run street cars) that sweep past curbed walks and patterned and natural parks are proof of its expected longevity.

Since permanency of the community is tied up with the size of the ore deposit and rate of extraction, on the basis of present production the city has a life expectancy of about 300 years. As long as iron remains in demand, the permanency of Kiruna is thus fairly well assured.

CREDOS

Creation's aeons are too long
For finished creeds. He must be wrong
Who knows the substance and the sum.
Is there no wonder yet to come?
No revelation to be heard?
Time has the final word.

RUTH MARY WEEKS

Audubon and Nuttall

JEANNETTE E. GRAUSTEIN

Dr. Graustein (Ph.D., Radcliffe, 1927) has been teaching biology at the University of Delaware since 1930. As a graduate student she was intrigued by the amusing stories of the idiosyncracies of Thomas Nuttall as told by members of the staff of the Gray Herbarium, but she found the published accounts of Nuttall's life marred by many gaps and discrepancies. This prompted a prolonged search for material for a complete and authentic biography. An unexpected find was an unknown 1810 journal of Nuttall which has been recently published in Chronica Botanica. *The present article discusses an association of Nuttall overlooked by his biographers.*

OF THE many friendships which grew from the impact of John James Audubon's buoyant nature on sympathetic contemporaries, that formed between him and Thomas Nuttall, who was regarded at the close of the second decade of the nineteenth century as America's foremost botanist, has been curiously overlooked or given slight attention by the biographers of both men. No biography of Nuttall has referred to Audubon. Francis Hobart Herrick in his epochal work on Audubon makes no mention of Nuttall until 1836 when the Nuttall-Townsend collection of new and rare Western American birds reached the East and became a possible source of material for Audubon's drawings. Herrick assumes that Audubon and Nuttall met at that time as strangers. This was far from the case. The two were already friends and had exchanged practical help that had been mutually appreciated.

Their first meeting is enthusiastically recorded in a letter from Audubon to Dr. Richard Harlan, of Philadelphia, written on August 14, 1832, while on his first visit to Boston, and now preserved at the Historical Society of Pennsylvania: "Nuttall is a Gem—a most worthy, agreeable Man—quite after our heart, and I am very happy to know him *as such.*" Harlan and Nuttall had long been active members of the Academy of Natural Sciences of Philadelphia, and as Harlan in answering Audubon's letters asked to be remembered to Nuttall it is likely that he had given Audubon a letter of introduction to the botanist, who had been established for almost ten years in Cambridge as curator of the Botanic Garden and instructor of botany and zoology at Harvard, and whose interest in birds was evidenced by his occupation at that time with the publication of a *Manual of the Ornithology of the United States and of Canada.*

On August 14, Audubon wrote also to his friend and patron, Edward Harris, of Moorestown, New Jersey, that he had ". . . made drawings of 3 rare species; one is the Marsh Wren, for which I searched in vain when near Salem; the 2d is a Flycatcher, described by Mr. Nuttall and the last a Thrush." The first two were used as Plate 175, Nuttall's Lesser Marsh Wren, and Plate 174, the Olive-sided Flycatcher, and the third, doubtless, as Plate 164, the Veery; they were published in 1833. Although Audubon does not mention the source of the specimens, it is obvious that they were furnished by Nuttall. The flycatcher, *Nuttallornis borealis* (Swains.), was a new species, recently discovered at Mount Auburn, which Nuttall had not yet published. Such generosity was indeed evidence of a spirit Audubon had not always encountered in ornithologists.

Audubon's initial endeavors in 1824 to establish a plan for publishing his drawings had met with bitter opposition from those financially interested in Alexander Wilson's pioneer work on American ornithology. The attack was led by George Ord, of Philadelphia, who had completed Wilson's work after his untimely death in 1813, and was then working on the third revised edition. This hostility remained inflexible. Ord also infected the eccentric English naturalist Charles Waterton, of prolific pen, who never wearied through the years in attacking Audubon. Rivalry in publication was at the root of all the smear tactics from which Audubon's reputation suffered.

When Audubon first met Nuttall he knew that the *Manual of Ornithology* was in process. A year and a half before, he had written from Edinburgh to McMurtrie in Philadelphia, "What sort of work is Nuttall publishing?" He very possibly had misgivings of again meeting with jealous animosity, or

at least unfriendliness. Relief seems to be reflected in his early warm appraisal of Nuttall.

To be sure, the publications of the two men had entirely different purposes, and were antitheses in treatment, size, and cost: Audubon's centering in an amazingly beautiful, ambitious, and expensive collection of engravings, and Nuttall's a modest, low-priced handbook in two volumes, with woodcuts almost as wooden as Wilson's engravings. Moreover, Audubon had devoted his life to the study of American birds, and Nuttall, heart and soul a servitor of Flora, probably thought of his *Ornithology* merely as a textbook for his students. He acknowledged that much of it was compiled from European and American publications. Tradition has it that Nuttall's good friend, James Brown, who was starting on publishing ventures with various partners, persuaded him to undertake the project. However, unpretentious though it was, the *Manual* filled a need so well that Charles C. Little and James Brown brought out a second edition in 1840 when opportunity for incorporating the new Western species was furnished by Nuttall's prolonged stay in Boston to give the third series of Lowell Institute Lectures. Indeed, near the turn of the century Little, Brown and Company brought out three editions only slightly revised.

The value of the *Manual* centered in the first volume, which discussed the land birds, most of which the author had observed long and patiently in the field, as well as a surprising number as pets in captivity. This volume was published in 1832 and certainly was near completion at the end of 1831. No personal reference to Audubon appears in it. The second volume covered the water birds, with which generally Nuttall had less acquaintance. It was finished in 1833, and contained numerous acknowledgments of facts furnished by Audubon, chiefly observations made during his Labrador expedition in the summer of 1833. At the end of his Labrador diary Audubon wrote:

> We reached New York on Saturday morning, the seventh of September. . . . Whilst at Boston I wrote several letters, one very long one to Thomas Nuttall, in which I gave him some account of the habits of water birds with which he was unacquainted; he sent me an extremely kind letter in answer.

We have a record of Audubon's first reaction to the volume in a letter which he wrote on February 15, 1834, from John Bachman's in Charleston, South Carolina, to his son Victor, who was in London in charge of the publication of the plates: "Nuttal [*sic*] has published a Volume of Water Birds which I am sorry to say is not equal to his first on the Land Birds—nay so far from it that for his sake I wish it was unpublished." And a few days afterwards he wrote to Edward Harris: ". . . have you seen Nuttall's Water Birds? The reduction of Gulls will be awfull when I come out with the truth respecting this Genus . . ."

Nuttall had labored prodigiously on the *Manual,* urged by a great compulsion—he had hopes, if not plans, of collecting in the Far West. In his earlier days he had botanized in the Old Northwest, up the Missouri and the Arkansas and in intermediate country. His "vegetating," as he called it, at the Botanic Garden and in the classroom at Harvard began in the spring of 1823. Although his duties afforded long periods of time when he was free to go, for instance, on a 1500-mile walking tour through the Southeast, he became restive. His discontent was brought to a climax in 1831 by the plans his friend Nathaniel Jarvis Wyeth was making to lead an expedition over the Oregon Trail to the Columbia River, with the hope of wresting from the British a share of the fur trade and weakening their claim to the Pacific Northwest, the ownership of which still hung in the balance. The United States had a title to the territory through the discovery of the Columbia River in 1792 by Captain Robert Gray, the expedition of Lewis and Clark, the founding of Astoria at the mouth of the river in 1811, and the cession by Spain in 1819 of all claims to the Pacific coast north of 42°. However, during the War of 1812 the British had seized Astoria and had since held a complete and jealous monopoly of the fur trade of the whole Columbia basin. Wyeth cherished the idea that action should be taken to sustain the American claims—an idea being energetically spread by Hall J. Kelley, a Boston schoolteacher. Wyeth was an able, vigorous young man, successfully established in the ice business with Frederic Tudor, but his gnawing vision led him to form careful plans for a Western expedition. That the Fellows of Harvard College voted in June 1831 to take steps to induce Nuttall to continue at the college may be interpreted as an indication of the naturalist's temptation to join Wyeth. The expedition left Boston on March 1, 1832, without him. It was not a fortunate venture; at Pierre's Hole, the 1832 rendezvous of the Rocky Mountain Fur Company, the party was involved in a disastrous ambush by the Blackfoot Indians, whose enmity was a heritage from the Lewis and Clark Expedition. Thence many turned homeward, lacking the courage to proceed farther, among them a young cousin of Captain Wyeth. Back in Cambridge, with the help of the quarrel-loving Dr. Benjamin Waterhouse, he attempted to save face

by publishing an unpleasant attack on the whole undertaking. Wyeth, meanwhile, with a handful of men, completed the trek down the Columbia. At Fort Vancouver, they were received with characteristic kindness by Dr. John McLaughlin, the chief factor of the Hudson's Bay Company west of the Rockies.

On July 4, 1833, from the western slope of the Rockies, on his return trip, Wyeth wrote to Nuttall:

DEAR SIR–

I have sent through my brother Leon[d] of New York a package of plants collected in the interior and on the west coast of America somewhere about Latt. 46°. I am afraid they will be of little value to you. The rain has been so constant where I have been gathering them that they have lost their colours in some cases, and they will be liable to further accident on their route home.

I shall remain here one more year. You if in Camb-[ridge] may expect to see me in about one year from the time you receive this. I shall then ask you if you will follow another expedition to this country in pursuit of your science. The cost would be less than living at home.

I have several times attempted to preserve birds to send you but have failed from the moisture and warmth. Excuse the shortness of this as I have many letters to write and little time to do it.

Resp'ly Yr. obt. servt.
NATH'L J. WYETH

Yet the next day, from Captain Bonneville's camp, he wrote to Dr. McLaughlin that he now expected to reach home in October.

Early in November Wyeth was writing from Cambridge, urging plans which resulted in the formation of the Columbia River Fishing and Trading Company, financed at least in part by Henry Hall of Boston. The second expedition was to start in the spring from St. Louis.

Nuttall went to Philadelphia to work at the Academy of Natural Sciences on the Western plants which Wyeth collected for him, and quickly completed the analysis of them and finished two other botanical papers which he left in charge of Dr. Charles Pickering for publication. The tantalizing revelations of the richness of the Far Western flora may have tipped the scales toward a positive decision, for Nuttall's letter of resignation to President Quincy of Harvard is dated only ten days before he set out from Philadelphia to join Wyeth in St. Louis. With him went a young ornithologist, John Kirk Townsend, whom he had encouraged to accompany him. Townsend received $100 from the Academy and the same amount from the American Philosophical Society toward his expenses, and in return agreed to give each institution a specimen of all objects he collected.

There are numerous indications that Nuttall was not happy in Cambridge. That neither an adequate library nor herbarium was available there was not the kernel of the difficulty. He loved the wilderness; like Audubon he was in harmony with the natural environment; his craving for it probably exceeded Audubon's, for Nuttall was not gay and social in disposition like his friend. Above all else, he yearned for frontier country and the intellectual excitement of encountering unknown plants and natural scenes. After the thrills of his early career of collecting many new species of plants and unfamiliar minerals, viewing strange geological formations and varied habitats—prairies, plains, deserts, forests of the north and of the south, of the mountains, the piedmont and the coast, bogs, and marshes fresh and salt—maturing scientifically in such exhilarating conditions, the Eastern states proved "stale, flat and unprofitable." As the financial pinches of the past gradually receded in his memory he began to look on the many years he had spent at Harvard as time lost from scientific exploration. Time had been flying by him, but he was still vigorous enough at forty-eight to make the arduous trip to the West Coast. Such an opportunity was too enticing and too rare to resist. However, he was not without concern for his economic situation, for he made a half-hearted suggestion of a leave of absence in the middle of his letter of resignation.

Audubon commented on Nuttall's adventurous journey soon after his departure from Philadelphia on March 13, 1834. At this time Audubon was on his way north from the Bachmans' to New York City to sail for England. He stopped two days in Philadelphia with the Harlans. On April 5 he wrote to Bachman:

. . . Nuttall & Townsend are off to the Pacific to catch Salmon and Salt the same for the Eastern Markets–Nuttal will not seize those in the manner of others or shoot them as *we* could do for the good fellow cannot swim a Yard and I believe never had a Gun to his shoulder.

On the next day he wrote to Bachman's sister-in-law, Maria Martin, who painted the plants for many of Audubon's plates: ". . . Nuttall & Young Townsend are left for the Pacific under charge of M[r] Wirth of Boston—I fear the expedition will prove a failure."

Audubon and Lucy sailed on April 16, 1834, for England with additional subscriptions, and drawings of the birds which he collected in Florida in 1831–32, in Maine and New Brunswick in the summer of 1832, and along the coast of Labrador in the summer of 1833. By the time of his next return to America almost 350 plates had been completed for *The Birds of America,* as well as the first three volumes of the *Ornithological Biography,*

the text which described the plates. On this trip his younger son, John Woodhouse, accompanied him; they landed in New York early in September 1836. On September 7, Audubon wrote to Lucy in London:

> Harlan has written saying that Nuttall and Townsend had forwarded about 100 new species of Birds from the Pacific side of the Rocky Mts! he has invited us to go and stay at his house during our visit to Philadelphia which I have accepted.

Two days later he wrote to Bachman:

> I had a letter from Edd Harris yesterday in which he enumerates the New Species of N. A. Birds collected by Nuttall and Townsend as follows,—"Several Hawks, Clarkes Crow, a Jay resembling the Floridian, Lewis Woodpecker and several New others, Evening Grosbeaks, Purple Grosbeaks, several New Fringillas, several thrushes, one Swallow, a black & white Sylvia, a Towee Bunting (Pipillio artica a good species which I found at Labrador also) Arctic blue Bird, Red winged Woodpecker and several others, a minute Titmouse, several regulus Wrens, Two or Three Tringas, a New Snipe, a vireo, several Fly catchers, Band Tailed Pigeon, a New Shrike, and Many others."
>
> Harlan writes me that this collection belongs to the A. N. S. of Phila. but that Townsend has Duplicates of them: Now I am anxious to Pourtray all those, and to publish them as an appendix to My present Work; but I have some doubts whether these Gents will allow me to do so? I have procured Two New Subscribers here, and have the promise of three more, but as I cannot withstand the desire to examine the rara avis at Phila, I will go there Monday morning and return here in a few days, then go to Boston, and thence move slowly towards the South, so to reach you all about the Middle or 20th of Octr. . . . .

And he wrote in answer to Edward Harris:

> Whilst running over the interesting list of the Species of Birds procured by Nuttall and Townsend in the Rocky Mountains, and the shores of the Pacific I became so completely wrapt up with the desire to see these as soon as possible that I have concluded to go to Philadelphia tomorrow by the 10 o'clock boat. I will stay at Harlan's for two or three days and hope that you will meet me there. . . .

The September 14 entry in Audubon's diary, as given by Buchanan, reads:

> . . . Went to market with Dr. Harlan. . . . After breakfast went to the Academy of Natural Sciences, met Dr. Pickering, and had a great treat in looking over and handling the rare collection made by Nuttall & Townsend in their excursion on and over the Rocky Mountains. It belongs to the Academy, which assisted the travellers with funds to prosecute their journey; it contains about 40 new species of birds, and its value cannot be described.

To no one were they of as great immediate value as Audubon, who in the tenth year of the publication of his elephant folio of *The Birds of America* was faced with a critically diminished number of subjects to complete it. Moreover, he wanted his treatment to be as full as possible.

Unfortunately Audubon's implacable enemy, George Ord, had been for years vice-president of the Academy. He and his clique forestalled Audubon in his efforts to obtain the birds for painting. Audubon, far from despairing, left the matter in the hands of his friends (Edward Harris offered $500 for the purchase of the skins) and took his way to Boston as he had originally planned. As fortune would have it, he was therefore one of the first to greet Nuttall, whose ship happened to reach Boston harbor "in the afterglow of sunset" on the very day on which Audubon arrived there.

Nuttall had returned around Cape Horn on the *Alert*, which carried a cargo of hides to Boston from California ranchos, and by strange coincidence this was the journey which completed Richard Henry Dana's "two years before the mast." Dana records amusingly the embarkation of the naturalist at San Diego the previous spring:

> This passenger—the first and only one we had had, except to go from port to port, on the coast—was no one else than a gentleman whom I had known in my smoother days, and the last person I should have expected to see on the coast of California,—Professor Nuttall, of Cambridge. I had left him quietly seated in the chair of Botany and Ornithology in Harvard University, and the next I saw of him, he was strolling about San Diego beach, in a sailor's pea-jacket, with a wide straw hat, and barefooted, with his trousers rolled up to his knees, picking up stones and shells. He had travelled overland to the Northwest Coast, and come down in a small vessel to Monterey. There he learned that there was a ship at the leeward about to sail for Boston, and, taking passage in the Pilgrim, which was then at Monterey, he came slowly along, visiting the intermediate ports, and examining the trees, plants, earths, birds, etc., and joined us at San Diego shortly before we sailed. The second mate of the Pilgrim told me that they had an old gentleman on board who knew me, and came from the college that I had been in. He could not recollect his name, but said he was a "sort of an oldish man," with white hair, and spent all his time in the bush, and along the beach, picking up flowers and shells and such truck, and had a dozen boxes and barrels full of them. I thought over everybody who would be likely to be there, but could fix upon no one; when, the next day just as we were about to shove off from the beach, he came down to the boat in the rig I have described, with his shoes in his hand, and his pockets full of specimens. I knew him at once, though I should hardly have been more surprised to have seen the Old South steeple shoot up from the hide-house. . . . I was often amused to see the sailors puzzled to know what to make of him, and to hear their conjectures about him and his business. . . . The Pilgrim's crew called Mr. Nuttall "Old Curious," from his zeal for curiosities; and some of them said that he was crazy, and that his friends let him go about and amuse himself in this way. Why else a rich man (sailors call every man rich who does not work with his hands, and who wears a long coat and cravat) should leave a Christian country and come to such a place as California to pick up shells and stones, they could not understand. One of them, however, who had

seen something more of the world ashore, set all to rights, as he thought; "O, 'vast there! You don't know anything about them craft. I've seen them colleges and know the ropes. They keep all such things for cur'osities, and study 'em, and have men a purpose to go and get 'em. This old chap knows what he's about. He a'n't the child you take him for. He'll carry all these things to the college, and if they are better than any that they have had before, he'll be head of the college. Then, by and by, somebody else will go after some more, and if they beat him he'll have to go again, or else give up his berth. That's the way they do it. This old covey knows the ropes. He has worked a traverse over 'em, and come 'way out here where nobody's ever been afore, and where they'll never think of coming." This explanation satisfied Jack: and as it raised Mr. Nuttall's credit, and was near enough to the truth for common purposes, I did not disturb it.

Dana was mistaken in tracing Nuttall's route to California directly from the Northwest Coast. He had spent both winters in the Sandwich Islands. In this way he lost no time contemplating the dormant vegetation of the North and had an opportunity to see the Hawaiian flora. In the spring of 1835 he had returned to the Columbia for a long season of collecting there and in the spring of 1836 he sailed to Monterey, the Spanish capital of Upper California. At Monterey, Santa Barbara, San Pedro, and San Diego he had added precious natural objects of all sorts to those already garnered from vast regions scientifically untouched. Many naturalists in America and Europe were waiting in eager anticipation to see or hear reports on the varied harvest of this superb collector.

Buchanan quotes from the September 21 entry of Audubon's diary a chatty account of his reunion with the botanist:

Called on Dr. Storer and heard that our learned friend Thomas Nuttall had just returned from California. I sent Mr. Brewer after him, and waited with impatience for a sight of the great traveller, whom we admired so much when we were in this fine city. In he came, Lucy, the same Thomas Nuttall, and in a few minutes we discussed a considerable portion of his travels, adventures, and happy return to this land of happiness. He promised to obtain me duplicates of all the species he had brought for the Academy at Philadelphia, and to breakfast with us to-morrow, and we parted as we have before, friends, bent on the promotion of the science we study.

In the entry for the next day appears: ". . . Nuttall breakfasted with us, and related much of his journey on the Pacific, and presented me with 5 new species of birds obtained by himself, and which are named after him. . . ." In a letter to Bachman the number of new species is given as six. A few days later Audubon records a dinner party evidently given by Benjamin D. Greene, president of the Boston Society of Natural History, at which President Quincy of Harvard and Nuttall were among the guests. Shortly after, Audubon went to New York on his way southward.

On October 23 Audubon wrote from Philadelphia to his new young friend Thomas Brewer in Boston:

Where is my learned friend Nuttall? Not a word has any person here received from him as yet, although he himself has been expected here for the past two weeks. Should you see him, pray give him my kindest remembrances, and communicate to him the following interesting facts:

Dr. Morton of this city, who is the corresponding secretary of the Academy of Natural Sciences, has kindly allowed me to portray the species of birds collected by Messrs. Nuttall and Townsend during their expedition to the Rocky Mountains, the shores of the Pacific, etc, found on American grounds. The Doctor has done more: he has sold me 90 odd of the skins, forming a portion of the collection. . . .

On the same day he wrote Bachman in jovial vein:

Now Good Friend open your Eyes! aye open them tight! Nay place specks on your probosis if you chuse! Read aloud!! quite aloud!!!—I have purchased *Ninety Three Bird Skins!* Yes 93 Bird Skins!—Well what are they? Why nought less than 93 Bird Skins sent from the Rocky Mountains and the Columbia River by Nuttall & Townsend!—Cheap as Dirt too—only one hundred and Eighty Four Dollars for the whole of these, and hang me if you do not echo my saying so when *you see them!!*

Early in November, Audubon wrote from Baltimore to Bachman that he had a few butterflies for him from Nuttall, and a few days later from Washington to Dr. Harlan:

. . . Tell him [Edward Harris] also to Come on to Charleston as soon as he will please, although I intend to remain there some time to Draw all my birds & Nuttall's Plants & Butterflies. . . . My sincerest thanks and best good wishes to generous Nuttall, and beg of [him] to finish his account for me of the birds he found. . . .

A week later Audubon had reached the hospitable home of Bachman, where he spent the winter drawing the Western birds. Those that Audubon received from the Academy were duplicates from the Townsend collection, and all new species were to be published with Townsend as author under specific names agreed upon by Nuttall and Audubon.

In the spring of 1837 Audubon accompanied by his son and Edward Harris collected along the Gulf of Mexico as far as Galveston from a revenue cutter put at his disposal. In midsummer he returned to England for the last time and, in somewhat less than two years, saw completed the plates of *The Birds of America* and the last two volumes of the *Ornithological Biography.*

The Nuttall-Townsend collection supplied about seventy figures for more than a tenth of the 435 plates. As a group they are not among the most

admired of the paintings. They often lack the animation usually depicted in the birds which the artist knew in the field, and they also suffered in most cases in their settings, for Audubon, unfortunately, was not supplied with information about the habits of the birds until after the paintings were completed. Many were painted without background, the birds perching on bare branches. For most, a vague imaginative scene was sketched of barren plain or stream bank and distant mountains with no plants or with some unidentifiable grasses. For some, Nuttall had happily supplied nests, and his Western butterflies were introduced in others. In several of the most pleasing the Western birds are shown nonchalantly perched on Eastern plants. The most successful compositions to a naturalist's eye are the two plates in which strictly Western plants furnish resting places for the birds. One of these, the Band-tailed Pigeon (Plate 367), shows the striking Northwestern dogwood with six white involucral bracts, instead of the four of the well-known Eastern species named, for its discoverer, *Cornus Nuttalli* Aud. The other, Four Western Corvids (Plate 362), shows the California sycamore, *Platanus racemosa* Nutt., and a magpie named for Nuttall.

Audubon depended on Nuttall and Townsend for descriptions of the Western birds for the fourth and fifth volumes of the *Ornithological Biography*. For the new species there was no other source of information, and for those that had been collected by earlier explorers the published facts were often meager. At the end of October 1837, about a year before the fourth volume appeared, Audubon wrote urgently to the dependable Edward Harris. He wanted to receive immediately the new birds that had recently arrived in Philadelphia with Townsend and moreover he wanted detailed statements of the habits, dates, localities, nests, eggs, songs, migrations, and all else Townsend knew concerning any and all birds he had seen on his journey. At the moment he seemed to regard Townsend as a desperate last hope: ". . . I am *exceedingly* [anxious] to receive a letter from him (for Nuttall, though an excellent friend of mine and a most worthy man, will not answer me in time on this subject). . . ." Nuttall proved not too dilatory, however, for both volumes contain page after page of exhaustive and beautiful descriptions by the "learned and obliging" Nuttall—far more complete than Townsend's and covering many more species. Moreover, Audubon quoted freely from Nuttall's *Manual*, explaining on one occasion that "none can describe the songs of our different species like Nuttall." Nuttall thus repaid a thousandfold the assistance Audubon had given him with his volume on the water birds.

Nuttall's contributions show verbal artistry worthy to be paired with the brushwork of Audubon. Part of his description of the black-headed grosbeak serves as an example:

> On the central table-land of the Rocky Mountains, and on the upper branches of the Colorado of the west, we first heard the powerful song of this most delightful Finch. From thence, in the thick groves of all the streams on our western course to the borders of the Columbia, and throughout the dense forests of that river nearly to the sea, we were frequently cheered amidst the wildest desolation by the inimitable voice of this melodious bird. Jealous of all intrusion on his lonely and wild haunts, it was seldom that we had the opportunity of witnessing this almost fairy musician, which gave a charm to the saddest gloom, and made the very woods as it were re-echo to his untiring song. With the modesty of superior merit, and almost with the solicitude of the Nightingale, our favourite Finch seeks the darkest thicket of the deepest forest. The moment his eye rests on the intruding observer he flits off in haste, calls to his mate, and plunging into the thicket sits in silence till he is satisfied of the restoration of solitude, when he again cautiously mounts the twig and pours out afresh the oft-told but never-tiring tale of his affection and devotion to the joys of nature. His song, which greatly resembles that of the Red-breasted Grosbeak, is heard at early dawn, and at intervals nearly to the close of night. It is a loud, varied, high-toned and melodious fife, which rises and falls in the sweetest cadence; but always, like the song of the nightingale, leaves a sensation of pleasing sadness on the ear, which fascinates more powerfully than the most cheering hilarity. In fact, the closing note of our bird is often so querulous as to appear like the shrill cry of appealing distress; it sinks at last so faintly, yet still so charmingly on the sense. When seen, which is only by accident, he sits conspicuously on some lofty bough, below the summit of the tree, and raising his head, and swelling his throat with a rising motion, almost amounting to a flutter, he appears truly rapt in ecstasy, and seems to enjoy his own powers of melody as much as the listener. Even the cruel naturalist, ever eager to add another trophy to his favorite science, feels arrested by his appeal, and connives at his escape from the clutch of the collector.

Similarities in the lives of Audubon and Nuttall are striking. They were born within a year of each other and grew up in a European atmosphere—the one in France, the other in England. As young men they came to an America, where only limited seaboard areas had lost the primeval quality. Stimulated by enthusiasm for the animal and plant life of the undisturbed hinterland, they labored happily and indefatigably on the frontiers of the natural history of the Western world, pushing knowledge of it far forward. It is surprising that they did not meet in their roamings for both covered much of the same territory, and more than once on the Ohio and Mississippi they must have been within a

few miles of each other. Unlike Audubon, Nuttall was not privileged to remain in the country to which he had devoted his talents. The inheritance of an English estate, agreed to years before in the interest of his family, forced his reluctant return in 1842, his fifty-seventh year, "almost an exile," to the land of his birth.

Over and above the monuments these men raised through their work, their memories are associated with organizations of great significance in the life of today. The first ornithological organization to develop in America was formed in Cambridge in 1873 of a few devotees gathered together by William Brewster; this was named the Nuttall Ornithological Club, after the first student of the birds of the Cambridge region. From it sprang in 1884 the American Ornithologist's Union (A.O.U.), the arbiter of all scientific work on American birds. The later-formed National Audubon Society and the affiliated state Audubon societies, "devoted to the protection and preservation of our native wildlife," are bringing before school children and adults the ideal of the conservation of our natural resources.

In these days when the American scene presents such changed conditions, it is pleasant to recall that the French *émigré* and the English botanist both found America a land of happiness, achievement, and fulfillment.

Bibliography

Manuscripts

Letters of Audubon. Houghton Library, Harvard University; Historical Society of Pennsylvania.

Minutes, Academy of Natural Sciences of Philadelphia.

Harvard College Records, Archives of Harvard University.

Publications

AUDUBON, JOHN JAMES. *Ornithological Biography.* 5 vols. Edinburgh: Black (1831–39). (The first volume was published by Adam Black; the last four volumes by Adam and Charles Black.)

———. *The Birds of America.* New York: Macmillan (1941).

AUDUBON, MARIA R. *Audubon and his Journals.* 2 vols. New York: Scribner's (1897).

BREWER, T. M. *Harper's New Monthly Mag.,* 61, 666 (1880).

BUCHANAN, ROBERT, Ed. *The Life and Adventures of John James Audubon, the Naturalist.* (Edited from materials supplied by his widow.) London: S. Low, Son, & Marston (1868).

CORNING, HOWARD, Ed. *Letters of John James Audubon.* 2 vols. Boston: Club of Odd Volumes (1930).

DANA, RICHARD HENRY. *Two Years before the Mast.* New York: Heritage Press (1947).

HERRICK, FRANCIS H. *Audubon the Naturalist.* 2 vols. New York: Appleton (1917).

YOUNG, F. G., Ed. *Sources of the History of Oregon.* Vol. 1. Eugene: University Press (1899).

SMO ON THE AIR

STATION	SPONSOR	TIME
	Sunday	
KLBM, La Grande, Ore.	Baker-Union Department of Health (Research Report)	10:15 A.M.
	Monday	
WOI-FM, Ames, Iowa	Iowa State College of Agriculture and Mechanic Arts (Articles of Interest)	7:45 P.M.
	Tuesday	
WEVD, New York City	Wendell W. Rázim (Science for the People)	9:00 P.M.
	Wednesday	
CKPC, Brantford, Ont.	The Telephone City Broadcast Limited (Modern Science)	9:45 P.M.
	(Irregular)	
KBKR, Baker, Ore.	Baker-Union Department of Health (Research Report)	....

The Editor of THE SCIENTIFIC MONTHLY will be glad to cooperate with university or other educational stations interested in securing scientific material suitable for broadcasting.

Western Cuba: Cultural Traverses in Time and Space*

RAY CRIST

So mobile is the author of this article that even the editors cannot put a finger on him, for he departed for the Near East shortly after his manuscript was accepted. Although he has worked and wandered widely over Latin America, much of his attention as a geographer has been devoted to the countries fringing the Caribbean. They will be his major concern again next September, when he returns to this country to take on new research responsibilities in the Department of Geography at the University of Florida.

IN HIS penetrating analysis of rural Cuba,[1] Professor Lowry Nelson quotes one of his informants as saying that "the country is the mother of the poor." This statement does not apply merely to Cuba, for in most of the world the peasant, the man who wrests his living from the soil, is not only proverbially backward and ignorant, but also miserably poor. Why is this so? Man is not a completely irrational animal that has evolved in response to the availability of certain plants or animals on which he could feed. If that were the case there would be a more direct relationship than at present exists between the actual food supply and the size of the human population; perhaps everyone would be miserably poor, on the verge of starvation, for the earth would simply be divided up into areas sparsely or densely populated, depending on the available food supply. Although man can live on many different food items, and has evolved manifold ways of making a living, agriculture still remains basic in most national economies. Then why does the country continue to be the mother of the poor? A study in historical perspective of the present cultural landscape of western Cuba might be revealing.

Western Cuba is composed of several distinct physical regions of relatively small extent. The infertile, thorn-scrub savanna coastal plains, in both the north and the south, are succeeded inland by outcrops of shales and slates that were once covered with dense forests of tropical pine trees. Most of the forests have long since been cut away, but the land is good for little else but reforestation in pine trees. The hard backbone of this part of Cuba is the world-famous *mogote* country, karst landscape classically developed: level strips of fertile land, known as *vega,* over which tower perpendicular limestone cliffs, hundreds of feet high. Drainage is mostly subsurface. Upon these physical features changing cultural landscapes have been superimposed.

Columbus discovered for his sovereigns a tropical island only slightly modified by its aboriginal inhabitants, the Taino Indians, who lived by collecting wild fruits and nuts, by hunting and fishing, and by engaging in primitive agriculture in a few zones. This tropical island, a land of dense forests interspersed with occasional grassy savannas, was a marvel to behold, as the Admiral wrote in his diary. But, a prey to quaintly childish wishful thinking, he wrote further: "The heat today has been frightful; I think it is due to the great quantity of gold and silver which is in the ground." Fortunately for the people of Cuba, little gold was found there, and the first settlers were forced to engage in agriculture.

Land was originally held in immense grants, made at first (1513–36) by the Crown and later (1536–1729) by the *Cabildos* ('municipal councils'); but it was hard to keep the population content with farm life during the conquest of Mexico and Peru, when glittering fortune beckoned from the mainland. Many answered the call of the siren, but those who stayed behind were able to make money breeding cattle and horses to be used by the conquistadors. Sugar planters were from the very beginning favored by legislation as well as by cash bonuses and subsidies—for example, by a *Real Cédula* of 1529 it bcame illegal for a sugar mill, together with its slaves, animals, and equipment, to be sold for debt.

But the great wealth in gold and silver that Spain

* The field and library work on which this article is based was made possible by a grant-in-aid of the Social Science Research Council. The author is also indebted to the Cuban Ministry of Education, and especially to Levi Marrero, superintendent of secondary education, for generous assistance in all ways.

was taking from Mexico and Peru aroused the envy of the other maritime nations of Europe, and their privateers and buccaneers preyed on the Spanish galleons. Faced with this situation, Spain began a system of convoys. Cuba was strategically located with reference to the channels of easy access to the Caribbean and the Gulf of Mexico, and Havana became the point where La Flota was assembled before leaving for Spain. The sailing vessels came out from Spain in the belt of the northeast trades, and on the return trip they sailed northward from Havana along the east coast of Florida until they reached the belt of the prevailing westerlies, which gave them a tail wind. In a day of great distances and slow boats, strategically located islands were important.

The presence of the great Plate Fleet in Havana was an immediate stimulus to agriculture, particularly to the growing of food crops (*frutos menores*). The Spaniards were mainly interested in conquests and in gold easily won, but they brought with them many converted Moors fleeing the Inquisition in Spain. The Moors had been the intensive farmers par excellence in the Iberian Peninsula. Many of them became artisans and small farmers in the new sparsely populated lands conquered by the *hidalgos*. The small farmers supplied the food crops, and the cattle ranchers provided the great quantities of jerked meat for the ships' crews, as well as beef tallow for the anchor chains. The forests of western Cuba furnished the hardwoods used first in repairing the ships of the fleet and later for the construction of small galleons and other vessels, in the first shipyards of the Antilles, in Havana.

The growth of the sugar industry was slow because of difficulties of transportation; sugar-cane plantations were concentrated around Havana, to which port the sugar could be profitably transported. Edaphic conditions were ideal; by the end of the sixteenth century there were already small cane fields that had been in production for forty years without having been replanted. It was only lack of capital that kept sugar from being exploited on a scale warranted by the ideal physical conditions.

Tobacco early began to play an active role in the economy of the island: it required relatively small amounts of land but a great deal of skilled labor. And the tobacco farmers, fortunately for the economy of Cuba, won their long battle with the cattle rancher. As Francisco Perez de la Riva points out, "The great estate was a castle of feudal privileges, whereas the tobacco farm was a cell of agrarian revolt."[2] The poor white laborer frequently used his small farm as a social ladder on which he was able to rise to bourgeoisie status.[3]

The lack of an expanding market in the mother country made the contraband trade flourish. Sugar, tobacco, hides, and dried and salt meats were exchanged for the silks, wines, laces, and linens brought to Cuba by Dutch, English, and French buccaneers. Not infrequently Spanish sailors bought such articles in Havana to sell in their homeland, where they were unobtainable, because war rather than industry was the concern of the rulers of Spain. The occupation of Havana by the English toward the middle of the eighteenth century revealed the commercial and agricultural possibilities of Cuba. The island was thus rediscovered by the Cubans as well as by the Spaniards, and even with Spain again in control the clock could not be turned back. The elimination of the old mercantilist controls revived agriculture and stimulated commerce. In 1779 Cuba exported 6,250 tons of sugar to Spain, but that was all the market could absorb. Money from Mexico, used to construct the new fortifications of Havana, stimulated commercial expansion.

Then came the great events that were to transform the economy of Cuba. The thirteen colonies of Britain revolted and established an independent country, which would become a great market for sugar. The slave revolt in Haiti caused 30,000 French people living there to flee to Cuba, many with slaves, capital, and the techniques of coffee growing—further, Haiti was no longer a competitor of Cuba in the production of sugar. Many royalist Spaniards moved to Cuba with their slaves and capital when continental Latin America achieved its independence from Spain.

With the nineteenth century came many developments in the sugar industry: the steam engine was introduced, transportation was improved, small mills were replaced by great factories, new techniques in chemistry were applied, and commercial treaties assured the island of markets for the finished product. The market continues to expand: Americans consumed an average of 43 pounds of sugar in 1880, 112 pounds in 1940. Already in 1895, Cuba produced more than 1,000,000 tons of sugar. But at what a cost—the cost of dependence on the outside world for its food. In the early days, Cuba was practically self-sufficient, but with the dominance of sugar all hands were used in its production. Labor could not be used in so mundane a business as producing its own food. The importation of beans, rice, dried codfish, jerked meat, and lard seemed justified in view of the high price of sugar in the world market. In this way the foundation was laid for an economy whereby a

land capable of tremendous agricultural production became dependent upon outside sources for its foodstuffs.

Then came, in rapid succession, independence from Spain, the entrance into Cuba of tremendous amounts of foreign (chiefly American) capital, and World War I, with its growing demand and high prices for sugar. The large holdings grew larger on some of the most fertile land as sugar became the dominant crop, and larger but fewer mills demanded more and more cane. The "dance of the millions" in the early 1920s was followed by a terrific depression, bringing home to the people the disadvantages of a one-crop economy. As the amount of land in sugar increased, so did the number of landless farm people. By 1927 the government sensed the danger and forbade the further cutting down of virgin forests for the expansion of cane fields; it also reduced cane acreage, which forced farmers to attempt to find alternative ways to use their land.

On February 5, 1942, a decree was published obligating all producers, including sugar mills, *colonos,* and farmers having an area of more than 166 acres, to devote a specified minimum portion of their land to the cultivation of rice, grain, peanuts, beans, and food crops other than sugar cane. In various sectors land was distributed in small plots to farmers who had been landless, and the federal government also helped many rural dwellers to obtain clear titles to the land they had been working.

Ex-President Grau San Martín, in presenting deeds of ownership of land to farmers in eastern Cuba, stated that agrarian reform is indispensable: "In Cuba we do justice without the need of copying foreign doctrines which are in conflict with our way of thinking. . . . This is not merely a partitioning of land, rather it is a return of rural property to the people who can use it. We aim to improve living conditions in rural areas and to achieve stability for the Cuban farmer."[4]

But the most effective land reform would seem to be that which places a premium on greater productivity, thus benefiting the national economy as well as the farmer.

One of the handicaps to agricultural development in Cuba for centuries was the lack of transportation facilities. During the early phases of its history Cuba was completely peripheral. Those areas that could readily get their products to a port were the ones to develop first. Many areas of exceptionally rich soil had to await the development of the railroad and the highway. The products of the rich tobacco soils of *vueltabajo* were in the beginning shipped to La Coloma on the south coast, thence coastwise by small sailing sloop to Batabanó, and thence north overland to Havana. The construction of railroads and of highways, especially of the Central Highway, has integrated the physical and economic units of the island, and has made possible the streamlining of various agricultural and manufacturing activities.

Development of domestic rice production. The cultural landscapes of certain sectors of western Cuba have undergone significant changes as more and more of the foodstuffs consumed or canned on the island are domestically produced. Rice has been for many years, and continues to be, one of the staples in the Cuban diet. It is hard to fix precisely the date when it was first introduced into the island. There is a record of its introduction into Puerto Rico early in the sixteenth century, and it was probably introduced into Cuba at about the same time. It doubtless assumed even greater importance in the diet with the importation into Cuba of thousands of Chinese, accustomed to eating much rice; many of them became cooks, thus making the eating of rice even more popular. Great quantities of rice are imported each year; the annual average for the years 1939–48 was 215,000 tons, and the amount imported in 1949 rose to 295,500 tons. When the price of sugar dropped precipitately in the twenties, with the result that there was little foreign currency with which to pay for imported rice, Cubans were in a bad way. Then began the campaign to grow more foodstuffs on the island itself, and the policy was given more vigor by the laws passed in 1927, decreeing a high tariff on many foodstuffs. But rice still continued to be imported in large quantities. The shipping shortage during World War II brought home even more poignantly the disadvantage of depending on foreign producing areas for a basic foodstuff. One fortunate factor was that rice in Cuba generally did not compete with cane for land.

With the cessation of hostilities, it was possible to import the machinery necessary for the production of rice on a large scale. In the vicinity of Consolación del Sur thousands of acres of land are now producing rice. This open savanna, covered with coarse grasses and scattered low shrubs and tall palms, was formerly used for cattle grazing. Land that in 1945 sold for $60.00 a *caballería* (33 acres) is now selling—if available—for $1,000 or more a *caballería.* The best of the savanna land is selected for rice cultivation. As one rice planter pointed out, "Here you look up and not down to determine the type of soil—where the royal palm

Typical uncleared parkland savanna, with scattered palm trees, bunch grass, and scrub oak.

Extensive fields of irrigated rice on cleared savanna.

Pump house and irrigation ditches on rice plantation.

Field of rice grown without irrigation on small farm near Herradura.

The Hoyo del Ancón, near Viñales.

Planting sweet potatoes near Viñales.

Early morning view across the *vega* through the Puerta del Ancón.

Viñales, showing *vega* broadening out.

grows, the soil is suitable for rice production." Chemical fertilizer is used on most rice plantations, to the amount of 200 pounds to the acre. This costs $87.50 a ton. The zone in which rice is being produced is underlain by an easily accessible water-bearing stratum, which is extremely productive. From one 120-foot well 5,500 gallons of water a minute are being pumped. All steps in the production of rice are mechanized—jeeps, tractors, power pumps, threshing combines, and hullers are used.

An average yield of 500 hundredweight of rice per *caballería* is profitable (*negocio*). But on some of the plots yields of 600–800 hundredweight have been obtained.

Wise rice planters are not putting all their eggs in one basket: the activities of the cattle ranch are being intensified. The production of beef is still important, but attention is being paid to the improvement of the dairy herd. With the development in Cuba of a domestic dairy industry, the importation of canned milk from the United States, a heavy trade up to 1927, has practically ceased. The demand for milk has everywhere increased on the island, and ranchers are preparing to meet this demand. The problem of transporting the milk to market was for long almost insuperable, but jeeps are now available for this purpose.

One of those who have made substantial investments in the growing of rice is Señor Ramon Acosta Diaz, who owns and operates a large ranch near Herradura. He has much uncleared land still devoted to extensive grazing, and the small acreages of fertile bottomland are planted in tobacco. He is clearing more of his grazing land each year in order to plant rice, the growing of which he has found exceedingly profitable. He has recently built a commodious ranch house, La Jocuma, where he lives with his large, closely knit family. Here typical Latin-American family solidarity, plus the exceedingly comfortable physical surroundings, makes for a gracious way of life rarely found in the present prosaic workaday world.

Pineapples and cooking bananas. Another interesting development in western Cuba during the past two years has been the new acreage devoted to pineapples and bananas on the north coast in the vicinity of Margajita. The total number of pineapple plants set out prior to 1950 was 270,000, but during 1950 and 1951 nine *caballerías,* or 297 acres, have been planted with 170,000 dozen pineapple and 98,000 plantain plants. The completion of the road along the north coast has made cheap transportation possible and of course has played an important role in the development of this area. The pineapples will be especially valuable in supplying the canning factories that are being established or are expanding output. Cooking bananas are a basic foodstuff on the island; the cheaper they are the better for the working people.

Agrarian problems in mixed farming areas. The rice and pineapple growers are optimistic in view of expanding markets and an abundance of land for future development. But farmers in the region of the beautiful, rugged, limestone mountains, which overlook level stretches of remarkable fertility, are caught between the upper and the nether millstones, between rising rents and cost of necessities, and stationary or falling prices for farm produce. One can best get at the farmers' problems by talking to them leisurely in their scrupulously clean houses. They are extremely friendly and hospitable; the passerby is always asked to come in and sit down, and he is invariably pressed to have "something"—usually a cup of strong coffee saturated with sugar. Then one can talk about children's diseases, or the banana blight, or methods of storing sweet potatoes. It is in these intimate chats that one sees the agrarian problem at firsthand. Luis Cabrera, a farmer who lives near Viñales, pointed out with no bitterness in his voice that his father, who had died fourteen years before at the age of seventy-four, had paid rent all his life and that his father's father before him had been a renter. "Think how many times my family has paid for this land I work [about 17 acres]. And I'm paying rent, too, and I see no possibility of ever being able to stop paying rent, or to acquire land, or to better my condition." It was at this juncture, after finishing off his cup of black coffee, that he quietly remarked: "The owner of the land ought to be the man who tills it."

By way of greeting seventy-one-year-old Amalia Lopez, of Laguna de Piedra, I asked her what was new in her part of the world. The reply was a laconic *"Figúrase!"* Literally translated, this means "Just imagine!" but from the tone of voice one senses the real meaning is, "Just imagine anything new ever happening here!" But as I sat and chatted with this matriarch, while her granddaughter was preparing for her guest a big glass of hot, salted milk, it came out that, actually, many changes had taken place since she had come to this area as a bride in 1902. On the *vega,* or land under cultivation, where two families were living and working fifty years ago, there were now seven, all with many children. She herself had had eleven children, of whom seven, with their families, were living in the same neighborhood. As she said, she had "sprinkled the countryside" with her children.

Of course the land was worked more intensively now, but rents were higher, too. And prices of the things that had to be bought were increasing. She complained that she could not serve me coffee because it was too expensive. There has been a steady parceling out of land into smaller and smaller plots—all rented, not owned by the operator. When asked whether living was more pleasant now than when she was young, she first waxed enthusiastic about certain modern material advantages—lights, roads, schools—but she felt that there was more wrangling, more political bitterness, less satisfaction with one's lot and work, less actual happiness. "And there are always the mounting rents to pay. You seem to work harder every year, and yet have less to show for it."

Severino Martín and his son-in-law were working a little less than a *caballería* of land on the trail to Ancón. Formerly Señor Martín paid $50.00 a year money rent and then he was free to grow whatever crops he pleased. When the agreement terminated, the landlord decided to have his land worked on shares, charging one third of the tobacco crop as rent. The crop in 1951 was 37½ hundredweight of tobacco, which sold for $22.50 a hundredweight, or $843.75. One third of that is $281.25—nearly six times what he had formerly paid in money rent. As he made the calculation, he nodded in the direction of his handsome twelve-year-old son and said, "That money should have been for him and his brothers instead of for the landlord, who has just left his palatial home in Havana for a three months' stay in Paris." On some farms the landlord gets one third of the tobacco crop, on others he gets one third of the corn crop as well. The terms of the sharecropping arrangement seem to depend on how good a bargain the renter can drive with the landlord. To give up one third of the corn crop works a real hardship on the farmer, to whom corn is almost an essential; it keeps better than bananas or the root crops, and is as important in fattening hogs and chickens as it is for food. Fertilizer is used for the tobacco crop, and the food and feed crops that follow it are thereby benefited. If the farmer cultivates corn on shares, as well as tobacco, the landlord tries to have corn follow tobacco. But the other food crops, yucca, yams, and *malanga* (similar to the taro of the Pacific islands), are grown year after year without fertilizer and with little attempt to improve the soil and increase yields. Rotation of crops is not practiced. The corn is of the common yellow type, called *criollo,* and no attempt has been made to introduce the hybrid variety. The perpendicular limestone cliffs around the Martín farm are definite physical boundaries, but they are no more effective in limiting production than are the routine farming techniques and the rent and marketing arrangements. Even the money for the cash crop, tobacco, is paid Martín at the pleasure of the landlord, even though he has to sell at harvesttime when prices are lowest. And he must also pay warehouse charges for the period that elapses between the date of delivery of his crop to the buyer and such time as he receives his check.

Jesus Rodríguez was of the opinion that "the big boy eats the small farmer. Coffee prices go up to where we cannot afford to buy it any more; matches, cloth, and other necessities continue to rise in price, but not tobacco. Yet when we have foodstuffs for sale we get only one third to one half of what they are sold for in the market of Pinar del Rio—only thirty miles away. We do the work, the middlemen take the profit." He complained that everybody seems to band together to *meter candela al veguero* ('turn the heat on the small farmer'), but that the farmers did nothing in the way of organizing for self-defense. When Cortez came to Cuba he was offered extensive landed properties, but his reply was, "I came to America to get rich, not to work the land like a laborer." Fortunately this attitude, prevalent during much of the colonial era, has all but disappeared in much of Cuba, for the Gallegos and Canary Islanders (*Isleños*) have successfully transplanted in the New World their Old World tradition of hard work. But the man who works hard and gets little or no return cannot but lose heart in the end.

Juana María Matas, thirty-two-year-old mother of seven children, when complimented on the fine looks of her brood, replied with some asperity that "the little fellow is the slave of the big boy, especially in the country." She explained that in making that statement she was thinking of her children, and of the poor start in life they would have as a result of living on a small farm in a remote sector; the trails to the main road were quagmires of red mud when it rained, and the education that one could get in the small village school was rudimentary in the extreme. It was true, she continued, that on a farm children were assets instead of liabilities at an early age—running errands, hoeing weeds, minding the animals, fetching water, and so on—but what chance had they of bettering themselves in the struggle for a livelihood? There was soon to be an addition to the family, and this mother felt strongly that her family was already large enough, if not too large. Families of eight to twelve children are the rule in the

country, and a large percentage live to maturity. This part of Cuba is relatively salubrious, with a resultant low rate of infant mortality. One parent after the other, mother and father alike, expressed joy in their children, but all were aware of the difficulty of supporting more than three or four on the small tobacco farms. In many homes, at least two or three adolescent boys or young men, and often as many or more girls, were working in town or were looking for work. The carrying capacity of the country has reached its limit unless technological improvements, hybrid seed, animal and chemical fertilizer, and so on, are introduced.

Most of the farmers want to see a clean sweep in politics, and they were for the most part devoted followers of the late Senator Chibás, whose party emblem was a flag with the design of a pair of crossed brooms, by way of illustrating what he planned to do if elected president in the 1952 elections. Chibás was their New Deal, their last hope, a veritable Messiah. The feeling of dissatisfaction on the part of the great majority of country people is such that no government can afford to ignore it, and agrarian reform is prominent on the list of the planks of those running for for high office. Many farmers complained of the huge budget for education, saying that teachers are paid from it who live in the towns or villages and never put in an appearance at all at their schools.

At the edge of the rich red limestone soils are found the soils derived from the disintegration of the shales, which are poorer than the *vega* lands, whether *tierra fina* (slightly loamy soil), or *tierra gruesa* (heavy clay). And the rents are proportionately higher on the poorer soils. One housewife told me that the landlord got a fourth of everything produced, including the charcoal made when the land is cleared. "If we catch a gourd of rain water you can be sure he will demand his fourth," she complained, not without bitterness. It seems to be a pattern of poor soil, high rents, poor people. One cannot but wonder: Have these families been pushed off the good soils by better farmers? Do poor farmers have to take marginal land, or does marginal land make poor farmers? Is there a definite correlation between marginal farmers and marginal land and good farmers and good soil? It would be a rewarding study to investigate the families in the transition zone between the fertile limestone soils and the poor, pine-covered shales.

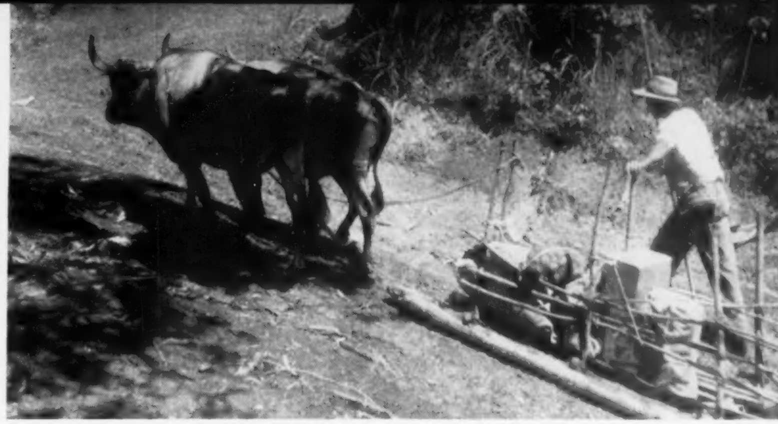
Rich Land, Poor People?

Cuba is often spoken of as a country where the land is very rich and the people very poor. But the Spaniards did not look upon Cuba as a rich island. To them Mexico and Peru were far richer, and money from Mexico was remitted to Cuba to make up the annual deficit in the cost of the civil and military administration. To the mercantilist mind, fertile soil was not even potential wealth. Cuba is spoken of as being a rich country by those who think in terms of modern agricultural techniques, power machinery, and expanding markets.

Capital will prefer to move into the areas where large-scale mechanized agriculture can be practiced. It will be difficult to make general farming an undertaking that will attract capital and at the same time compete for labor on a reasonably even footing with urban employment. There is often a tremendous spread between the price the farmer receives for his produce and the price the consumer ultimately pays. It is suggested that producer and consumer cooperatives might help eliminate unnecessary costs of handling and transportation and losses caused by poor storage facilities, etc. The farmers' cooperatives of Holland and Denmark and the Federacion Nacional de Cafeteros of Colombia might be studied by farmers' groups in Cuba with the idea of incorporating their best features in local cooperatives.

The pressure on agricultural resources is reflected somewhat in the nascent industrial growth. The purchasing power for consumer goods increased enormously in Cuba during World War II, when such items could not be readily provided by the United States and Europe as in the past. As a result, consumer goods industries, largely financed by domestic private capital, have begun to flourish. Even limited industrialization brings many problems in its wake, however. The exodus of rural people to the cities has become a tidal wave, with the consequent growth of slums. Such basic urban services as pure drinking water, sewerage, electricity, and paved streets are available only to a part of the city population, especially in the new industrial sections, with a resulting increase in health and social hazards. It is fortunate that the speedy and relatively cheap bus service that is available, now that new roads are being

La Jocuma, a commodious Cuban ranch house.



Ox-drawn sleds are much used on the steep trails.

built in many districts, makes it possible for many young people to live in the country and to commute to work, or at least to spend week ends with the family.

The thousand-page World Bank report on Cuba, presented in August 1951 to the Cuban Ambassador to Washington—who jokingly remarked that the report was practically as big as Cuba—recommends that the island develop a program with the following ends in view: (1) Make Cuba less dependent on sugar, by promoting new industries but without restricting the production of sugar. (2) Expand the present, and create new, industries that will process products in which large amounts of sugar are used. (3) Promote the export of products other than sugar, in order to reduce the overemphasis on sugar exports. (4) Produce on the island more foodstuffs for domestic consumption, as well as many other raw materials and consumer goods that must be imported at present. In other words, the authors of this report collectively arrive at the conclusion that Cuba should continue on the course projected by the legislation of 1927, which has been imbued with new vigor since 1945.

It should be pointed out that Cuban social legislation has closely followed the suggestions made in 1927 by Ramiro Guerra y Sánchez in his classic volume *Azúcar y Población en Las Antilles.* In this volume the dangers inherent in the tremendous growth of the sugar latifundia are exposed, and a rapid increase in the number of owner-operator holdings is advocated. With more people owning land, the amount of foodstuffs produced domestically would increase and smaller amounts would be imported, the general standard of living would rise, and the insular economy would be less dependent on one export crop. In the *Revista Nacional* of April 1947, one reads: "Agrarian reform cannot be improvised. We must tackle it now as a step forward in stabilizing our economy."

Fortunately, since Cuba still has much land not as yet intensively worked, agrarian reform has largely meant the opening up of new areas that lend themselves to large-scale mechanized farming. The tariff on imported foodstuffs has made profitable the domestic growing of food crops, and this fact has of course greatly influenced those with capital to invest. By the investment of local capital in large-scale agricultural enterprises as well as in industry, the Cubans have effected changes in the economy of their island during the past generation about as rapidly as is possible in a democracy.

A discussion of those areas given over almost exclusively to the growing of sugar cane or tobacco is beyond the scope of this paper. The goal has been rather to study within a relatively limited area some manifestations of the reciprocal action of nature on man and of man on nature, which is the very heart of geography. Investigations were made of certain sectors that are forging ahead in agriculture and of others that are declining, or at best are barely able to maintain production. Some highlights in the historical background have been brought out in order that recent developments might be viewed in perspective. Every effort has been made to give proper weight to the influence of the physical and the cultural factors in the evolution of the present-day cultural landscape.

In western Cuba in the past the most fertile soils have been used for the production of sugar and tobacco in a one-crop economy, and poorer sectors have been devoted to the production, by primitive methods, of foodstuffs for local consumption. There are, however, vast tracts of land as yet uncultivated, which with the aid of modern agricultural techniques could produce foodstuffs for immediate use as well as for canning. By the application of capital, vision, and technology, agriculture can be made profitable in these areas, as has already been demonstrated in the growing of rice, pineapples, and bananas. As more food crops are produced domestically, imports of foodstuffs will decline, and there will be more foreign currency available for the purchase of the mechanized equipment and manufactured goods that are costly to produce in Cuba. Purchasing power will be distributed on a wider base, levels of living will inevitably rise, and the colonial situation—in which raw materials are exported and foodstuffs are imported—will disappear.

References

1. Nelson, L. *Rural Cuba.* Minneapolis: Univ. Minnesota Press (1950).
2. Perez de la Riva y Pons, F. *Origen e Régimen de la Propiedad Territorial en Cuba.* Havana: A. Muñez y Hno., 117 (1946).
3. Tuthill, R. L. *Economic Geog.*, **25**, (3), 201 (1949).
4. San Martín, G., Quoted in P. G. Minneman, *Agricultural Attaché Report No. 191* (May 13, 1947).

The Function of Proverbs in the Intellectual Development of Primitive Peoples*

EDWIN LOEB

The author, a member of the staff of the Department of Geography of the University of California at Berkeley, received his Ph.D. at Yale in 1922. He was a lecturer in the California Department of Anthropology during 1922–33 and in the Department of Geography during 1950–51. From 1928 to 1929 he was a Guggenheim Fellow and during World War II an OSS expert on the Dutch East Indies. Dr. Loeb has made expeditions to Polynesia, the Dutch East Indies, and to Southwest Africa, where he gathered the African data appearing in this article.

FROM the days of Auguste Comte, the founder of sociology, until the turn of this century, the intellectual development of the human race, when considered at all, had, so far as I know, never been denied. Various schemes to gauge this development have been advanced, and each of them argued for an advance in group intelligence, or "culture," rather than for an advance in the innate intelligence of the individual. It has generally been admitted that Cro-Magnon man reached the apex in brain development for the human species. From the late Pleistocene on, man, like the beaver, has, in the main, worked by adapting his environment to suit himself rather than by adapting himself, through the process of evolution, to suit his environment. The direct result of man's intellectual development has been an increase in human population per square mile. Keith[1] estimates the total human population of the earth in mid-Pleistocene as 4.2 millions (one inhabitant for each ten miles of habitable territory) against the present over 2 billions. The advance of the individual has come about through education, and this education is not an inherited trait. Every human being, whether he be Bushman or Englishman, starts life's competition from cultural scratch.

* Based on a paper read at the first meeting of the Western Branch of the American Oriental Society, November 24, 1951, at the University of California, Berkeley.

Among various devices to gauge man's cultural advance have been the "stages of civilization" (savagery, barbarism, and civilization) of Henry Morgan,[2] and the growth of *Lebensfürsorge* (provision for the future) of Julius Lippert.[3] At the beginning of the twentieth century, however, Boas and his followers in American ethnology turned upon the believers in unilineal evolution and destroyed our implicit belief that all change in the cultural context of a people was by necessity upward and onward. Thus, a change from polygamy to monogamy might be inconvenient for the primitive hoe cultivators of Africa, where women do all the agriculture, and certainly native feudalism and indirect rule work better in English Africa than do the direct rule and perhaps the private ownership of land in the French and Belgium possessions. The school of functional anthropologists, headed by Malinowski and Radcliffe-Brown, has performed praiseworthy service for colonial science by adopting the motto that, in general, a custom is good or bad according to whether it functions with the total culture. In making this determination, however, historical perspective is not needed, and the functionalists are noted for their neglect of history, both reconstructed and dated.[4] Moreover, since progress can only be observed in historical perspective, the functionalists are apt to deny human progress altogether.

Theory or no theory, however, few if any social

scientists have denied advance in material culture. For most purposes the *Queen Mary* is superior to a dugout; an electric razor is easier on the skin than a sharpened flint.

Of recent years, Leslie White has advocated a unilineal scheme for measuring the advancement in civilization which is both qualitative and quantitative. Progress, he states,[5] depends on the work energy developed per capita. Thus, domesticated animals give more power than slaves, steam is still better, electricity furnishes a further improvement, and atomic energy will presumably be at the apex.

The question now arises: Does advance in the material realm necessitate intellectual advancement? I believe that it does. In this paper four increments of intellectual progress will be discussed which will be approximately correlated with White's unilineal scheme. These are play-thinking, or imitative magic; the use of proverbs; and deductive and inductive reasoning.

Primitive hunters, fishers, and gatherers, such as the Bushmen of South Africa or the natives of Australia, have cultures that permit primarily a form of thinking which is in large part the imitative magic of Frazer[6] or the play-pretending of Frobenius.[7] Animals will not increase in number if the Bushmen hold a giraffe dance after killing a giraffe; but neither will they decrease. It is not that the adult Bushman is a child, but rather that his mode of thinking need not advance beyond the childlike.

More advanced than the hunters, fishers, and gatherers are the agriculturists and the nomadic or seminomadic breeders of large domesticated animals—goats, sheep, cattle, camels, the yaks, asses, and horses—here called cattle raisers. The agriculturists need more observation and inductive reasoning than the hunters, but their reasoning may well remain on a concrete level, with a large residue of imitative magic. Gardeners depend largely on timing and weather conditions, so among grain agriculturists (as distinguished from earlier root agriculturists) astronomy becomes of importance, as does magical rain making. Sexual intercourse is thought to influence crops, and gods must be ever-present and in concrete and local forms to safeguard the domains. Since early agriculturists have few movables, custom may remain law for an indefinite period of time, as among the corngrowers of North America.

With cattle raisers a great advance may be noted in human intellectual development. These people may be said to be predominantly abstract-minded—that is, able to formulate sweeping generalizations. As noted by Thurnwald,[8] it is the cattle raisers who are the first real capitalists, and not simpler peoples with pseudo money, such as the Hupa of northwest California, or the Trobriand Islanders of Melanesia. Cattle breed interest, which shell money does not. Cattle and capital are synonymous, and the first stock markets dealt in livestock and not in paper securities. Cattle are movables and demand protection; shell money and blankets may be hidden away. It was the cattle peoples everywhere who originally had proverbs, and these proverbs had the function of having been the general fund of primitive philosophy, ethics, and law. Religion among simpler peoples is of an entirely practical nature, on a *quid pro quo* basis. When proverbs, however, are attached to a religion it may take on an ethical form. Cattle people conquer early agriculturists, and the conquest usually is excused in terms of ethical necessity. This form of conquest often was the basis of sacred literature, as in the case of the Zend-Avesta, the Vedas, the Koran, and the Old Testament. Although, with the exception of the Old Testament, proverbs are not quoted in these sacred revelations, it appears not improbable to me that the conquerors imparted proverbs as part of their superior culture. This could have happened also in West Africa and in China, where today we have purely agricultural peoples who are noted for their proverbs. In North China, according to W. Eberhard,[9] proverbs are found in the literature of the eighth century B.C. But, in South China, which was remote from invading nomads, proverbs were not known until the beginning of the Christian Era when, in the Han dynasty, the North conquered the so-called southern barbarians.

Boas[10] was the first to state that proverbs were found in the Old World only and not in the new. But this fact, whether it will be found entirely correct for South America in pre-Spanish days, can be further refined. Proverbs were a distinct possession of cattle-raising peoples of the Old World and of some neighboring agricultural peoples. They were not found, for example, in Melanesia, Australia, New Guinea, among the Pygmies, or among the Bushmen of Africa. In Indonesia they extended as far as cattle—i.e., to Java and Sumatra—but not to the pig raisers of Bali. Coastal Malays, however, brought proverbs with them everywhere to coastal populations.

It will be useful to classify proverbs according to function in order to obtain additional light on man's early intellectual growth. This recently was done in greater detail for the Kuanyama Ambo, a cattle-raising Bantu tribe of Southwest Africa.[11]

1. *Legal proverbs.* In Africa, with the exception of the most primitive peoples, proverbs may be considered the beginning of law. Here, as among all cattle raisers, proverbs and law courts occur together. Non-cattle-raising people, such as the North American Indians, have neither law courts nor proverbs. Without courts, it is perhaps more proper to speak of tribally enforced custom rather than law.[12] Still proverbs are not law, in the full secular sense of the word. Laws normally are created by legislative bodies, and these did not exist until the days of the Athenian Greeks. Laws may be repealed or amended, but proverbs disappear in time.

"The Africans," writes Herzog of the Jabo of Liberia,[13] "are very legalistically minded. Since almost any act has legalistic aspects, there is hardly a discussion of any consequence (whether or not actually in court) in which proverbs are not employed."

Two legal proverbs for the Kuanyama are: "A person should not shoot a bird resting on his own head"—that is, Do not testify against a relative lest you harm yourself. "A messenger in service is never harmed"—A king's messenger has safe convoy.

2. *Ethical proverbs.* Instruction for the young is given in the form of proverbs, since these are easily remembered. "To give is to keep"—If you give something away, you may get more in return. In Christian ethics this would read, "It is more blessed to give than to receive." "At beginnings hard time, good in the future"—All beginnings are difficult.

3. *Philosophical proverbs.* Kuanyama philosophical proverbs are of a simple variety: "Skin new" —A new wife is well treated—in the beginning. "A wealthy person is a selfish person."

4. *Religious proverbs.* The ethical portion of Kuanyama religion is connected with the cult of the High God Kalunga, not with the ancestral sacrificial religion. Kalunga in pagan days was unconsciously identified with the sun, and was depicted as daily passing across the sky with two baskets on his back giving out food to the deserving, sickness to the wicked; hence the proverb "The baskets of Kalunga are equal in size." Another well-known Kuanyama proverb is "When a poor man cries for help, only God will aid him."

Oriental proverbs have not as yet been classified according to the above scheme. In China, however, which has long had a fully developed legal system, legal proverbs are now in the minority. Confucianism appears to be a system of religious, ethical, and philosophical proverbs woven around an archaic cattle-raising system of ancestor veneration.

In Indonesia the *adat recht* (customary rights) is merely a collection of customs. The Indonesians themselves had no word for custom, but used the Arabic word *adat*. The real law of western Indonesia existed in former times, and still does to a considerable extent, in the form of proverbs. For example,[14] the patrilineal Bataks of Sumatra defend the rights of women by stating that "a woman is no karabau, that she can be bought." The neighboring Minangkabau, who are matrilineal, defend their system by stating that "a rooster can lay no eggs." Hence the father has no rights over his children, who belong to the mother's brother.

Thus, we have two areas of the world, Africa and the Far East, where abstract thought, or generalizations, take the form of proverbs. The question arises as to whether these two areas received their cattle and their proverbs from a common source. This theory was advanced in 1950 in a paper called "Courtship and the Love Song."[15] In attempting to demonstrate this hypothesis, I used a fifth form of proverb, the love proverb. Among hunting, fishing, and gathering peoples, as well as among early agricultural peoples, marriage usually takes place at the time of puberty, for with some exceptions, such as on our own Northwest coast, there is no large marriage price to pay, and likewise no dowry. Among early cattle-people, however, a large marriage price is almost universal. Unless the young couple are betrothed at birth or early childhood, this payment involves delayed marriage, prolonged courtship, frustration, and the rise of our concept of "romantic love." During this courtship period in primitive times, and indeed even today among the Ambo of Southwest Africa, the Tuareq of the Sahara, the mountaineers of Switzerland, Albania,[16] and Tibet,[17] and the Bataks of Sumatra, the lovers exchange love proverbs. Invariably, except for the marginal area of South Africa, these responding proverbs are in the form of antiphonal rhymed verse, accompanied by melodious music. Melody, indeed, appears to be largely antiphonal in nature; among the cattle-raising mountaineers of Switzerland and Tibet, melody is enhanced by the yodel.†

Contrary to the impression created by *Indian Love Call* in Friml's operetta *Rose Marie,* the North American Indian had no antiphonal love songs, no rhymed verse, and probably no romantic love in our sense of the word—that is, idealization. Among the cattle-people of the Old World, however, antiphonal love songs are distributed in a

† Nicholas T. Mirov notes that the Turkic-speaking much-mongolized cattle people of Tuva, formerly known as Uriankhai, yodel at the time of festivals. They call this kind of singing either by a Turkic word, *sykyrtyr*, or by a Mongol word, *Khëëmei*. It is said that the yodel is also practiced in adjacent Mongolia.[18]

continuous chain from the Zulu of South Africa to the Bataks of Sumatra.

The argument for a single invention of the love song rests not only on its geographical continuity, but more especially on its identity in form and function. The form is always a quatrain, or a series of quatrains. The first two lines of the verse are descriptive of nature, the last two of human emotion. The first and third lines, and the second and fourth are supposed to rhyme. The girl utters the first two lines; the boy answers with the last two, or vice versa. Originally, antiphonal love singing, which actually is a form of riddling, was performed in contest, the girls distributing themselves as prizes. Granet[19] has described the same form of love song for the ancient Chinese, and similar love-making was enacted by the ancient Japanese. In Africa and Europe, temporary mating of a quasi- or entirely innocent nature takes place, or more generally took place at the time of such festivals, as is still done by the Ambo and the Swiss mountaineers. In the Far East, the premarital mating was of a more serious nature and occurred at the time of the Spring festival.

Gustav Meyer[20] in 1885 first described the diffusion of this type of quatrain throughout Europe, south Siberia, and the Far East. It is called *Schnaderhüpfel* by the Swiss, *chastushka* by the Russians,[21] and *pantun* by the Malaysian peoples. I suggest that the all-embracing term "proto-sonnet" might be used. The sonnet, as its name implies, was originally a short love song. Like the *pantun,* the sonnet first refers to nature and then to human emotions. Likewise, like the *pantun,* in the sonnet there is a sharp break—in this case, between the octave and the sestet of the strict Italian form. The fourteen lines of the sonnet give room for elaboration of rhyming schemes.

Five examples of the proto-sonnet, covering ground from Southwest Africa to Sumatra, are given below.

Swiss:

Zwa Fischl in Wosser,
Zwa Vöglan in Wold,
Und zwa Leut dõ si gern hobn,
Dö findn si bold.

Two fish in the water,
Two birds in the woods,
And two people who love one another,
Find one another quickly.

Kuanyama Ambo of Southwest Africa:

Look at the wild fig tree,
Look at its leaves.
People in love with one another
Look at each other in the face.

India:

The tree, beneath which we kissed,
Stands bare, with leafless crown.
And so has our youth departed
And our love, before we knew of it.

Chinese: From the *Shih Ching* ('Book of Odes'):

The poplars at the east gate!
How luxuriant their leaves!
At dusk we shall be waiting for each other!
How bright the radiance of the stars!

Batak of Sumatra:

Whence, little sister, cometh the leech?
From the rice field, down to the river.
Whence, little sister, cometh love?
From the eyes, down to the heart.

Although proverbs were man's first great attempt at abstract thinking, they were not a matter of discussion; their authenticity was not open to question.

A third accretion in the art of thinking arose with the philosophy and plays of the Athenian Greeks, especially in the fifth century B.C. Through dialectics the ancient world awakened to the possibility of discussion and deductive reasoning. I believe that it was no accident that Buddhism and Confucianism arose in the same century.

The fourth and last method of reasoning, inductive reasoning, became prominent in western Europe in the late eighteenth century with the beginnings of the Industrial Revolution. Experimental science, mathematics involving the time element and acceleration, the laws of probability, and inductive reasoning are just as much handmaidens of the Industrial Age as were proverbs the natural philosophy of the ancient cattle raisers.

Thus we have four phases of human thought succeeding one another alongside man's material progress. First comes play or magical thinking, the let's-pretend kind, then proverbs, next deductive reasoning, such as Plato's idealism, or the theory of the idea, and finally the objective reality of inductive science. Each of these is accompanied by less emotional context than its predecessor; each gives its user a diminishing amount of primeval pleasure. For this reason, the pathological mind of the senile or insane tends to revert to earlier forms of mentation. Ontogeny recapitulates phylogeny, and the child must be educated through these four phases, beginning with play in preschool age, and ending with research in upper division college or graduate years.

Finally, it may be observed that the proverb-making phase of mankind has never been given adequate study, probably because it was already

of minor importance in European classical times. Among many preliterate peoples, however, even of Europe, it was almost the only vehicle of instruction. A further proof that proverbs represent an early method of abstract thought may be surmised from the fact that superior individuals taken from peoples who are well versed in this variety of word usage, such as the Africans or Bataks, may readily be acculturated in universities, once they have had ordinary school training. Yet hunting and gathering peoples like the Bushmen and native Australians cannot thus be acculturated, and are commonly considered "backward races."

Even advanced early agricultural civilizations, as the Pueblo Indians or the Balinese, however high in artistic merit their elaborate masked ceremonies may rank, are on a different although not necessarily inferior, level from that of Western industrial civilization.

References

1. Keith, A. *A New Theory of Human Evolution.* New York: Philosophical Library, 270 (1949).
2. Morgan, L. H. *Ancient Society.* New York: Holt, 12 (1877).
3. Lippert, J. *Kulturgeschichte der Menscheit.* Stuttgart: Enke, 3 (1886).
4. Murdock, G. P. *Am. Anthropol.,* **53,** (4) Pt. 1, 468 (1951).
5. White, L. A. *The Science of Culture.* New York: Farrar, Straus, 368 (1949).
6. Frazer, J. G. "The Magic Art," in *The Golden Bough,* 2 Vols., London: Macmillan (1932).
7. Frobenius, L. *Kulturgeschichte Afrikas.* Frankfurt: Phaidon-Verlag, 167 (1933).
8. Thurnwald, R. In *Die Menschliche Gesellschaft.* Berlin: Walter de Gruyter, 161 (1932).
9. Eberhard, W. Sinologist's Research Information. Berkeley: Univ. Calif.
10. Boas, F., Ed. *General Anthropology.* New York: Heath, 598 (1938).
11. Loeb, E. M. *Anthropological Records,* **13,** 4, Berkeley: Univ. Calif. Press, 322–31 (1951).
12. Lowie, R. H. *Social Organization.* New York: Rinehart, 156 (1948).
13. Herzog, G. *Jabo Proverbs from Liberia.* London: Intern. Inst. African Languages and Cultures, 2 (1936).
14. Loeb, E. M. *Sumatra: Its History and People.* Vienna: Institut für Völkerkunde der Universität Wien, 71, 111 (1935).
15. ———. *Anthropos,* **45,** 821 (1951).
16. Frasheri, S. B. *Pledge of Honor: An Albanian Tragedy.* Trans. and ed. by N. Drizari. New York: Vanni, 20 (1945).
17. Hermanns, M. *Die Nomaden von Tibet.* Vienna: Verlag Herald, 239 (1949).
18. Kaschenko, B. P., *et al. Our Country* (in Russian). Moscow: Ministry of Education, 238 (1949).
19. Granet, M. *Festivals and Songs of Ancient China* (trans.). London: Dutton, 11 (1932).
20. Meyer, G. *Essays und Studien zur Sprachgeschichte und Volkskunde,* Vol. 1. Strassburg: Karl J. Trübner, 289–412 (1885).
21. Lopatin, I. A. *J. Am. Folklore,* **64,** (252), 179 (1951).

ULTIMATE

Whether by flame or ice,
Or by the lightning wings of pestilence,
We shall go, we know not.
But this we know:
In a million years, more or less,
Man shall look his last upon the stars.
Over him darkness shall walk the years
And lead the last faint mind into the abyss.
Eternity shall turn to him and say,
"There is no fear but my fear,
And no death but my death."
So in its last journey, the mind
Shall go out and be as one with space and time.

Daniel Smythe

SCIENCE ON THE MARCH

SOME BEHAVIORAL EFFECTS OF OXYGEN LACK

Anoxia not only stops the machine, it wrecks the machinery—J. B. S. Haldane.

SCIENTIFIC interest in the effects of lowered oxygen tension on living organisms has existed for some time. As early as 1617 Stenonis is credited with having occluded the ascending aorta in the dog and observed a resulting paralysis of the rear extremities. Brown-Séquard is said to have demonstrated the order of interruption of central nervous system function in acute anemia in 1858. We know now that these men were subjecting their animals to stagnant and anemic anoxia, respectively. It was in 1878 that Paul Bert[1] showed that it was the diminished partial pressure of oxygen that produced the adverse physiological effects of high altitudes. Such anoxia, characterized by a decreased partial pressure of oxygen, has come to be called anoxic anoxia. Anoxia resulting from tissue cells being unable to utilize available oxygen is called histotoxic anoxia. An example is cyanide poisoning.[2]

Physiologists, neuroanatomists, and psychologists share a common interest in anoxia because of the peculiar susceptibility of the central nervous system to injury when the oxygen supply of the organism is reduced below certain critical levels. There is considerable evidence that, of all the tissues in the mammal, nervous tissue is the most sensitive to fluctuations in the normal oxygen supply.

There has been increasing interest in the possibility of permanent damage to nervous tissue and a consequent reduction of behavioral efficiency following anoxic exposure. Major impetus for this interest has come from two divergent areas: one, the possibility of exposure to high altitudes such as is encountered in military and commercial aviation;[3] the other, the possibility that intrauterine or neonatal anoxia may result in damage to nervous tissue, with consequent alteration in behavior in extrauterine life.[4]

Investigations of the effects of anoxia on the nervous system and on behavior may take many forms, but a major division of such investigations is to be found in the temporal relations existing between the exposure to anoxia and the observations desired by the experimenter. There are three possibilities. The study may be directed toward the acute or immediate effects of anoxia, toward the delayed or permanent effects, or toward a combination of immediate and delayed effects. This latter is referred to as intermittent anoxic exposure. The experimental work summarized here was carried out using anoxic anoxia and consisted of observations of any delayed effects of the anoxic exposures on both the nervous system and the adaptive behavior of certain animals.

Our experiments have centered on several questions. First, will sublethal anoxic exposures reduce the behavioral efficiency of an organism when the measurements of behavioral efficiency are made after anoxic exposure? Second, if detrimental behavioral effects are noted, how long-lived are they? Third, if detrimental behavioral effects are observed consequent to anoxic exposure, do they bear a quantitative relation to the amount of anoxic exposure? These same questions have been asked concerning the brains of anoxia-exposed animals. Is there demonstrable brain damage after sublethal anoxic exposures? If brain changes exist, how permanent are they, and is there a quantitative relation between such neural changes and the the amount of anoxic exposure? Finally, as students of behavior, we are interested in correlating changes in behavior with changes in the brain, in the hope that such inquiry will add to our knowledge of the anatomical and physiological events that underlie the behavior we are studying.

Two paradigms have been utilized in investigating the behavioral aftereffects of anoxia. In one, animals have been exposed to varying degrees of anoxic exposure, and their ability to learn *de novo* a complicated maze is compared with the performance of control animals. Here, the behavior experimentally isolated is predominantly learning behavior. In the other paradigm, normal animals *learn* a complicated maze, and then some of them are exposed to varying degrees of anoxia and their ability to *relearn* the same maze is compared with that of control animals. Hence, the behavior of interest here is predominantly relearning or *retention* behavior. These two paradigms are widely used by psychologists in their investigations of the effects of physiological and neuroanatomical variables on animal adaptive behavior.

We have characteristically induced anoxia by exposing animals to simulated altitudes. This is

achieved by the use of decompression chambers. Because we want to standardize our information about these phenomena, we have utilized an altitude of 30,000 feet (225 mm Hg pressure) and in many cases have kept the time at this altitude constant, from experiment to experiment. Several behavior experiments will be described here. In the first,[5] 120 albino rats were randomly divided into four groups destined to be subjected to 0, ½-hour, 3-hour, and 6-hour exposure to a simulated altitude of 30,000 feet. Six days after this treatment, half of the animals began the learning of a complicated maze. Seven weeks after anoxic insult the remainder of the rats began similar training on the same learning problem. This latter procedure will be recognized as an attempt to answer the question of the relative permanence of any behavior losses that existed. A consideration of the errors made in learning the maze indicates the nature of the findings. The animals beginning learning six days after anoxia made an average of 102, 109, 130, and 240 errors for the 0, ½-hour, 3-hour, and 6-hour groups, respectively. The seven-week group made an average of 107, 120, 180, and 130 errors, respectively. These differences are highly reliable when evaluated statistically and indicate an extreme likelihood that in this situation graded amounts of anoxia result in increased behavioral loss. The question of permanence of the damage is not unequivocally answered here. Further studies are being directed toward the permanence problem. We have repeated part of this work, substituting the golden hamster for the albino rat.[6] With this animal, learning the same maze, the error scores ran: 93, 112, 131, and 163, for animals beginning their maze training six days after exposure of 0, ½-hour, 3-hours, and 6-hours at a simulated altitude of 30,000 feet. These differences between groups are statistically reliable and are taken as indicating a decrease in learning ability proportional to amount of anoxic exposure.

In another experiment,[7] 84 rats, all of whom had learned a complicated maze equally well, were randomly divided into four groups and each group subjected to 0, ½ hour, 3 hours, or 6 hours at a 30,000-foot simulated altitude. Then, six days after these anoxic treatments the animals relearned the same maze. The following average error scores were made by the respective groups in relearning the maze to an equal degree of competence: Control group, 11 errors; ½-hour group, 18 errors; 3-hour group, 22 errors; and the 6-hour group, 27 errors.

These differences were found to be reliable, and they indicate a decrease in relearning ability that is related to the amount of anoxic insult. We have had several opportunities to make similar observations on rats in subsequent experiments, and the results generally indicate an inverse relationship between quality of performance and amount of anoxic exposure.

Behavioral evidence such as we have presented, coupled with the general concept of the susceptibility of the nervous tissue to anoxic insult, leads to the hypothesis that these behavioral and neural alterations are in some way related. Studies by such men as K. S. Lashley have demonstrated the dependence of maze learning and maze retention on the integrity of rats' cortices; hence, it is a reasonable hypothesis that the deterioration in learning and retention seen after anoxia is at least in part a consequence of cerebral cortical injury. Certain of our experiments were constructed so as to permit a test of this hypothesis. The animals in the first learning experiment described above were sacrificed 100 days after they had been exposed to the several degrees of anoxia mentioned, and their brains removed. The brains were prepared for microscopic examination with special pains being taken to keep conditions constant for the brains representative of the various experimental classes.

Two hypotheses were tested in this, the neuroanatomical, phase of the experiment. First, it was hypothesized that there would be fewer cerebral cortical cells in the brains of the rats exposed to anoxia than would be found in the brains of control rats. Second, it was hypothesized that the decrease in cerebral cortical cells would be greater as the degree of anoxia increased. It should be pointed out that if these two hypotheses were found essentially correct the question of relative permanence would be answered in the affirmative. One hundred days in the rat represent approximately one seventh of the animal's life span, and if evidence of brain damage were observed 100 days after the original opportunity for that damage to occur it would be presumptive evidence of permanency.

The tests of these hypotheses were based on a statistical sample of the cell destiny per unit of volume of the brains examined. It was assumed that the number of cells present in a large number of microscopic fields within particular areas of the cerebral cortex would represent justifiable estimates of the *relative* cell densities of those areas when comparisons were made from brain to brain. In order to justify these assumptions several possible sources of error had to be taken into account. First, all microscopic sections examined had to vary as little as possible in thickness. Accordingly, every brain examined was cut into serial sections 10μ

in thickness. Second, the possibility of a differential effect of the staining techniques had to be considered; that is, one brain might stain in such a way as to make more cells visible when the cell counts were made. In an attempt to control this source of error, brains were run through the preparatory processes in such a way that the different experimental classes were equally represented at each stage of the processing. Third, there was the possibility that even if the first two variables were negligible the counting procedure itself would be unreliable. To test this possible error source the reliability of the counting procedures was tested in two ways. After counts had been completed on all brains the internal reliability of the counts was determined in much the same way that the internal reliability of any test is determined (correlations were computed between odd and even microscopic field counts and between the first and last halves of the sets of counting data for each brain). The internal reliability of the technique was quite high (Pearsonian r's of .94–.96). The most convincing demonstration of the reliability of the counting procedure consisted of simply doing the work over and then correlating the results of the first and second counts. This yielded a Pearsonian r of .87. It should be pointed out that in all this neuroanatomical work the brains are coded so as to rule out experimenter bias.

The results of these procedures indicate that for the 16 brains that were completely processed there is a decrease in the cell density of animals exposed to anoxia 100 days before their brains were removed, and that in general cell density decreases as anoxic exposure increases. For example, the total cell counts made in 450 microscopic fields examined in each of 16 brains were as follows: control brains, an average of 15,542 conducting cells; ½-hour animals, 12,210; 3-hour animals, 11,959; and 6-hour exposure animals, 10,676 conducting cells. Statistical analysis of these differences permits considerable confidence in their reliability. The differences found in different areas, and in different lamina, of the cerebral cortices of these animals are discussed in more detail in a technical paper.[8]

From these studies it was concluded that the technique of sampling cell densities is a reliable one, and also that the observed decrease in brain cells as a function of increasing anoxia warrants further extension of the technique.

It is not possible at this time to construct correlations between individual rat's brain scores and their maze performance scores. More brains will have to be studied to carry out this very worthwhile task. It can be said, however, that the groups' scores for maze performance coincide with the groups' brain scores, and at this time the best guess as to why these animals (hamsters and rats) learn and relearn less efficiently after anoxia is that they have suffered permanent neural damage.

In experiments where the independent variables are of a physiological nature, and the dependent variables are measures of behavioral adequacy, a complete experimental analysis necessitates certain minimum information as to how the physiological alterations are related to the behavior changes. In its simplest form, this information is whether the obtained behavior differences are due to a change in learning or memory per se, or whether the changes in behavioral efficiency are the result of a primary change in the motivation of the experimental animals. A reduction in the motivation of rats following anoxic exposure could reduce maze performance just as effectively as a decrease in the amount of functioning nervous tissue. As a matter of fact, when one is correlating experimental or clinical brain damage with behavior, it is always possible that the reduction in nervous tissue lowers adjustive efficiency by decreasing the subject's motivation, and hence, only indirectly affects learning ability. In the course of analyzing our results with this question in mind, we made a surprising discovery—hamsters and rats appear to display an *increase* in motivation after anoxic exposure. This conclusion was arrived at in the following way.

Hamsters and rats were subjected to the several degrees of anoxia used in the previous studies and were then trained to run through a straight 18-foot alley to a constant amount of reward. The animals were kept on a rigid schedule of deprivation of the reward substance (in this instance, water). Constant deprivation and constant reward or incentive are the operations the animal psychologist uses to achieve experimental control of motivation. The 18-foot alley straightaway minimizes learning. The experimental question is, How fast will the animal run to obtain the needed substance? The rate of running is a relatively pure index of the degree of motivation. When 60 hamsters were equally distributed among experimental groups exposed to 0, ½, 3, and 6 hours at a 30,000-foot simulated altitude and then put through the motivational analysis described the results were as follows: The control animals averaged 18 seconds in traversing the 18 feet; the ½-hour group, 13 seconds; the 3-hour group, 11 seconds; and the 6 hour group, 11.8 seconds. As the degree of anoxic exposure increased, motivation, as defined here, increased. These differences were found when animals were

trained 11, 36, and 85 days after anoxic exposure. Similar results have been obtained with laboratory rats.[9] In view of these results we feel that the reduced maze performance of the animals we have studied is not explicable on the basis of reduced motivation.

At this time we are extending these essentially preliminary studies so as to investigate a wider range of anoxic exposures and a wider range of behaviors. With reference to particular behaviors (such as maze learning) we are attempting to determine more precisely the quantitative relations between amount of anoxic exposure and the resultant loss in behavioral efficiency. In other situations we are holding the amount of anoxic insult constant and are investigating the effects of this variable on behaviors of varying complexity and kinds (such as motivation, problem solving, etc.). It is our belief that not only are the phenomena studied of intrinsic interest but that they may offer information of value in understanding the "normal" variations in behavioral efficiency that are so conspicuous even in laboratory rats and hamsters.

WILLIAM P. HURDER

Department of Psychology and School of Medicine Louisiana State University

References

1. BERT, P. *Barometric Pressure*. Trans. from the French by M. A. Hitchcock and F. A. Hitchcock. Columbus, Ohio: College Book Company (1943).
2. VAN LIERE, E. J. *Anoxia, Its Effect on the Body.* Chicago: Univ. Chicago Press (1942).
3. ARMSTRONG, H. G. *Principle and Practice of Aviation Medicine*. Baltimore: Williams & Williams (1939).
4. SCHREIBER, F. *J. Am. Med. Assoc.*, **111**, 1263 (1938).
5. HURDER, W. P. *J. Comp. Physiol. Psychol.*, **44**, 473 (1951).
6. FISHER, G. A. The Effects of Three Degrees of Anoxia on the Golden Hamster's Maze Performance. Thesis, Lousiana State Univ. (1950).
7. HURDER, W. P. Changes in Maze Retention in Rats Following Exposure to Anoxia. Paper read before 42nd annual mtg. Southern Soc. Phil. and Psychol., Nashville (1950).
8. ———. *J. Comp. Physiol. Psychol.* (in press).
9. LATINA, R. J., and HURDER, W. P. Effects of Anoxia on Golden Hamsters' Rate of Running on Eighteen Foot Strait-A-Way. Paper read before 23rd annual mtg. Midwestern Psychol. Assoc., Chicago (1951).

PROPOSAL FOR AN EXPERIMENTAL STUDY OF METABOLIC CHANGES ACCOMPANYING INCIPIENT HUMAN CANCER*

ONCOLOGISTS feel that if the presence and site of active cancer in the human body could be discovered sufficiently early the rate of success of established methods of treatment, such as surgery and radiation, would at once increase very greatly. Much research work has, therefore, been done, and is being done now, in an effort to develop a laboratory approach to the problem of the reliable and early recognition of human cancer. The search for systemic changes accompanying the presence of cancer has produced many data and many leads. A large part of the January 1950 issue of the journal *Cancer* was devoted to a discussion of recent developments in this field. One of the articles[2] gives a comprehensive review of what has been done and accomplished; no specific consideration of individual experimental approaches is intended here.

There are, however, several generalizations that seem to emerge from the over-all picture. *First,* no physiological or chemical change has been discovered which is systemic, and truly specific for cancer. To varying degrees changes that are characteristic for cancer are also encountered in a variety of noncancerous pathological conditions.

Second, the values found for any particular class of cases—whether normals, cancer cases, or patients with one or the other of the nonmalignant diseases—generally cover a wide range, and the ranges tend to overlap between one class and another, although statistically the average or median value may be significantly displaced. The results are distribution patterns of the type shown schematically in Figure 1, with their overlapping fringes of so-called false positives and false negatives.

Third, there are few, if any, adequate studies in which several of the proposed tests have been applied simultaneously to the same clinical material, so that no significant conclusions are possible as to whether, for instance, several tests that may be positive for all or nearly all cancer cases show identical degrees and kinds of overlap with different noncancerous pathologies.

Fourth, the state of the cancer patient, or the state of cancer, is seldom adequately considered. Thus, one study may deal predominantly with ad-

* An extension of remarks made at the First Conference on Cancer Diagnostic Tests,[1] sponsored by the National Cancer Institute, U. S. Public Health Service, in Chicago on October 14, 1950; also supported by an Institutional Grant of the American Cancer Society.

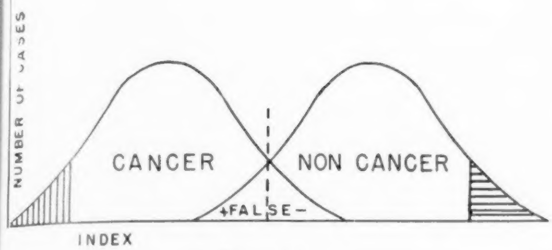


FIGURE 1.

vanced or terminal, hospitalized, cases, whereas another may chiefly cover early, ambulatory, patients.

Fifth, little consideration has been given to the question whether a given value of the concentration of a blood component or other index is a day-to-day constant in a given individual or whether, and to what extent, it undergoes normal fluctuations.

Sixth, whenever different classes of conditions have been studied, such as normal, cancer, or nonmalignant disease, each class has consisted of a different set of individuals. That is to say, it has not been possible to apply the procedure, commonly applied in experimentally induced changes in animals, of making measurements on the same individual "before and after." Thus, if with regard to a certain criterion a study on different individuals yields results of the type schematized in Figure 1, the possibility remains that those individuals who constitute the fringe of high values in the distribution pyramid of the cancer cases (the "false negatives") may have been part of the extreme high fringe of the normal pyramid before they developed active cancer. Similarly, it is conceivable that the "false positives" among the noncancer cases would be found among the extreme low fringe of the cancer curve if they were to contract cancer.

The foregoing considerations suggest a study concerning systemic changes associated with cancer development which should fulfill the following conditions: (*a*) a selected group of physiological or chemical criteria should be studied on the same individuals; (*b*) the study should involve the repeated application over an extended period of time of the same tests to the same individuals; (*c*) the study should be begun with a group of normal individuals which should be sufficiently large to yield, during a reasonable period of time, a statistically significant number of cancer cases, so that physiological-chemical changes accompanying the appearance of cancer in an individual would become evident and could be statistically evaluated.

In brief, the investigation, instead of comparing the physiological state of cancer bearers and noncancer bearers, would aim at revealing the physiological changes that accompany the development of cancer in an individual.

Investigation of Humans or of Experimental Animals?

It seems likely that an investigation of this type has not been carried out in the past simply because the scope of the enterprise would transcend the capacity of any individual laboratory or institution, especially if the data are to be obtained on human material. Would it not be more reasonable, then, to make a first approach of this kind by means of animal experimentation? A large number of cases and a substantial number of tests would have to be dealt with in order to obtain significant results, and experimental animals can be marshaled and controlled at much smaller cost than humans. The case for the direct approach to human cancer may be viewed as follows. Knowledge and control of human cancer are the actual objective. Any new perspectives on the physiological dynamics of cancer development which might emerge from an animal study would still require verification in human oncology in order to be made practically useful, and there is legitimate reason to doubt that the response of human physiology to cancer is identical with that of the mouse, the rat, or the guinea pig. The solution of the pernicious anemia problem has been long delayed because the syndrome of the human disease could not be reproduced in animals; poliomyelitis research is handicapped by similar difficulties; and in regard to cancer itself, it is well recognized that the host-tumor relationship, viewed merely in terms of the typical ratio between size of tumor and size of host, is very different in the ordinary experimental animal and in man. The specificity of the human problem is especially sharply pointed up by the fact that there is no satisfactory animal source of gastrointestinal cancer,[3] which is responsible for more than half of all human cancer deaths.

Any new knowledge that may accrue from a broad study of human physiological changes should be directly applicable to the human cancer problem and, besides, there is good reason to expect that the work may throw light on physiological changes accompanying or preceding other metabolic diseases, and thus become useful to medicine in an even larger area than that of cancer. Such expectation seems justified because the number of normal humans with which the study would have to be begun, and with which it would have to be carried

through, would necessarily be many times larger than the minimum number of cancer cases required for statistically significant conclusions. As a result, the investigation would encounter and cover in significant numbers other disease entities that normally occur in a broad cross section of the population.

Finally, the fact that many individual investigations into human cancer have been made, and will continue to be made, would seem in itself to justify the broad approach. For, if there are good reasons for the former approach, the same good reasons should apply to the latter.

What Tests and Measurements Should Be Made?

It is not the intent of this discussion to attempt the outline of a specific program. It would obviously be the task of a committee of experts from a variety of fields to decide upon the spectrum and range of tests and measurements, the techniques to be used, the frequency of examinations, and other specific points. It seems certain that the development of new techniques and promising new experimental findings during the past twenty-five years provide an ample and varied fund of possibilities from which a broad, well-reasoned, and coordinated program of measurements can be sifted.

If we were to assume for a moment agreement on the desirability of a project of the suggested type the question of feasibility would remain. The question of feasibility is largely the question of cost, and in order to make even the most tentative estimate of the cost of the program some conception of its physical magnitude is necessary. Approximately how many cases should be studied, how frequently, and for how many years?

As a basis of approach to a minimum estimate, one may tentatively postulate that at least one hundred cases of human cancer should be observed and studied from a point of departure of normal or average health to that of definite diagnosis. An estimate of the size of the sample of the average population needed to yield 100 cancer cases within, say, five years, requires a knowledge of the incidence of the disease. Readily available sources[4] show the following annual death rates from cancer in recent years: 0.13 per cent for the United States, 0.14 per cent for Illinois, 0.15 per cent for Delaware or Pennsylvania, 0.17 per cent for New Jersey, and 0.19 per cent for the city of Philadelphia. A partial study on cancer incidence conducted in Pennsylvania[5] showed that 46 per cent of all cases were among persons forty to fifty-nine years old and, since this group comprises approximately 23 per cent of the population, the frequency of cancer in this age group appears to be approximately twice as high as in the whole population. If we somewhat arbitrarily assume that the true average death rate is 0.16 per cent, that for every four persons who die of cancer there is one who contracts cancer but who, as a result of successful surgery, etc., does not appear as a cancer case in the death statistics, and that between forty and sixty years of age cancer is twice as frequent as in the whole population, we obtain an annual incidence of 0.4 per cent in that age group. Accordingly, a random sample of the population aged forty to fifty-nine should, within a period of five years, yield two cancer cases per hundred—i.e., the study should embrace 5,000 persons in order to cover the genesis of 100 cancer cases.

Let us further assume, arbitrarily, that the whole investigation is to consist of ten different tests or biochemical measurements, and that each subject is to be tested four times a year. If we assume that 200 days per year are available for the laboratory work, a single laboratory charged with the determinations to be performed on 250 subjects would have to carry out 50 determinations per day, a task that should be feasible for a laboratory staffed with three or four technicians. On this basis, 20 laboratories would be required to handle the 5,000 subjects contemplated. If these laboratories were placed in the five largest cities of the nation, with a combined population of nearly 20,000,000, 250 volunteers would have to be recruited from approximately each 250,000 persons of the desired age group—that is, one per thousand. Continuity of the program could be assured by the incentive of a $100 savings bond for each volunteer, to be awarded at the end of the five-year program. For administrative supervision the laboratories could probably be attached to existing medical or other scientific centers. For over-all supervision and coordination, and for the collection and analysis of data, a project director with a small staff would be needed.

A rough estimate of the total cost of this undertaking, built upon the suggested organization and facilities, would probably yield a figure in the neighborhood of $400,000 per annum for five years. This figure should be viewed in relation to the current national expenditure for purposes of cancer research and cancer control. A recent summary[6] of current grants-in-aid and institutional research grants devoted to cancer research by six leading organizations (American Cancer Society, Atomic Energy Commission, Babe Ruth Cancer Fund, Damon Runyon Memorial Fund, Jane Cof-

fin Childs Memorial Fund, and National Cancer Institute) shows an annual total of more than $7,000,000. If one makes allowance for the fact that this list does not cover all sources of private and public funds currently being used for cancer work, one thus arrives at the conclusion that the cost of the proposed new research program would not exceed 5 per cent of what the nation is now spending in the fight against cancer.

What Would Be Gained?

Is this cost too high, and is the expenditure justified? Obviously a cost of 5 per cent of the current national expenditure for cancer work is not too high in terms of the national capacity to pay. The question of whether the investment is justified must be considered in the light of the results that may reasonably be expected from the program. In terms of maximum gain, the least that could be expected would be the discovery, through this program, of a systemic physiological correlate, or correlates, of the appearance of active cancer in the human organism which would make it possible to diagnose and attack the disease at such an early stage that the chances of complete and permanent eradication by surgery and treatment would be vastly greater than they are at present. Beyond this the possibility can hardly be denied that new insights into the physiology of cancer might be revealed which might result in new methods of prophylaxis and treatment. Whatever positive knowledge of the scourge of cancer would accrue from the program would serve as an encouragement to the general population to enlarge its support of cancer research. And to the extent that the new knowledge would have direct practical usefulness, it would serve as an incentive to those of us who are interested in self-preservation, to submit to the inconvenience of voluntary periodic health examinations.

In minimum terms the projected study may be expected to eliminate a number of false leads or open up new viewpoints for future research attacks. Furthermore, although approximately 2 per cent of the subjects of investigation will meet with cancer during the five-year period, death will reach for approximately 20 per cent during that same period, according to statistical life expectancy data. Accordingly, other diseases, especially the metabolic diseases of middle age—i.e., heart and vascular diseases, nephritis and diabetes—will be encountered in substantial numbers, and the experimental data obtained should be helpful and useful in the fight for their suppression. Since research in heart and allied diseases at present receives federal support of a magnitude similar to or greater than that devoted to cancer, and since these diseases are responsible for an even larger fraction of deaths than cancer, it would even seem worth while to consider the possibility of broadening the experimental basis of the investigation to include specific consideration of other metabolic diseases, thus also broadening the financial basis of the work.

The present remarks will have served their purpose if they lead to a critical consideration of the suggested possibilities by investigators in this field and by those responsible in governmental and private organizations for the large-scale support of medical research. The scale of this type of support has tremendously increased during the past decade, and it is for that reason that a program which ten years ago may have been utterly utopian may deserve consideration now.

G. Toennies

The Institute for Cancer Research and
The Lankenau Hospital Research Institute
Philadelphia

References

1. *Proc. First Conf. Cancer Diagnostic Tests, Sponsored by the Natl. Advisory Cancer Council.* U. S. Publ. Health Service Pub. No. 96 (1950).
2. Homburger, F. *Cancer*, 3, 143 (1950).
3. Chalkley, H. W. Preliminary and Partial Analysis of Areas of Cancer Research Supported by Grants from the National Cancer Institute. Mimeo. (Oct. 1950).
4. *World Almanac* and *Bulletin Almanac*. Recent editions.
5. Reimann, S. P., Reeves, R. S., and Aronson, R. S. *Pennsylvania's Health*, 2, (4), 33 (1941).
6. American Cancer Society. Composite List of Active Fellowships, Grants-in-Aid, and Institutional Research Grants to Cancer Research from all Sources. Mimeo. (1950).

THE ANNISQUAM SEA-SIDE LABORATORY OF ALPHEUS HYATT*

THE largest and most renowned marine laboratory for research and instruction in North America is the Marine Biological Laboratory at Woods Hole, Massachusetts. Its turbulent but brilliant history has been traced by Frank R. Lillie,[1] with the cooperation of Edwin G. Conklin, who authored certain sections of the book, especially those concerned with the early historical background. Conklin has pointed out that contrary to common belief the Marine Biological Laboratory did not develop directly from the Anderson School of Natural History established by Louis Agassiz, but was an outgrowth of the Annisquam Sea-side Laboratory of Alpheus Hyatt.[2]

Before turning our attention to the Annisquam Laboratory, let us briefly review the development of seaside laboratories on the Massachusetts coast, as given in the writings of Lillie and Conklin, for perspective. The first marine summer school established in North America was the Anderson School of Natural History organized by Louis Agassiz on the Island of Penikese in 1873. Earlier, Agassiz had a small private laboratory near his summer home at Nahant, where he and his assistants carried out marine studies, but it was not formally organized as a school. The elder Agassiz died shortly after the first session of the Anderson School. The second session was in charge of his son Alexander, but he was forced to leave during the term because of ill health. The direction of the school for the remainder of the summer, the last in its brief history, was placed in the hands of A. S. Packard and F. W. Putnam. In 1877 Alexander Agassiz organized a private marine laboratory at his home near Newport, Rhode Island, which accommodated about a dozen assistants and research students, much as his father had done earlier at Nahant.

In 1880, and possibly for a year or two earlier, Alpheus Hyatt, curator of the Boston Society of Natural History and director of the Teachers School of Science, invited a few advanced students to carry out marine studies in two rooms he had outfitted as a laboratory in his home at Annisquam, an outlying village of Gloucester on Cape Ann. This building is an old colonial home, known by some as "Seven Acres" and by others as the "Norwood House." It was built in 1664 on a point of land between Goose and Lobster coves by Francis Norwoodde, who had been given the original grant of land of six acres. The property was purchased by Professor Hyatt in 1878 for taxes due. Two rooms on the first floor were devoted to his laboratory. The building still stands much as in its original form, although all that remains from the laboratory is a large oil portrait of a frog painted on the back of a door by a Miss Hintz, one of the summer students. On a granite boulder behind the house is a bronze plaque, sculptured and placed there by Mrs. Alfred G. (Hyatt) Mayor. The inscription reads:

> Alpheus Hyatt as Curator of the Boston Society of Natural History instigated and directed the Teachers School of Science of Boston. Aided by this society and the Woman's Educational Association he established a Sea-side laboratory that had its birth in his house at Annisquam 1880. The Marine Biological Laboratory of Woods Hole is an outgrowth from this laboratory and Alpheus Hyatt was its first president in 1888–90. Born 1838—Died 1902.

Also in the summer of 1880, Hyatt had a private vessel built for use in his marine research and instruction. This was a two-masted schooner 58 feet long and weighing 17.32 tons, constructed at the shipyards of Boothbay Harbor, Maine. She was named the *Arethusa,* after the mythical Greek wood nymph by that name who was pursued by the river-god Alpheus. Rescued by Artemis, Arethusa was transformed into a spring that ran under the sea. An amusing parody on the classical name appeared in the *Cape Ann Advertiser*[3] as follows: ". . . the latest addition to the fleet of 'Squam is the 'Are You Through, Sir,' a handsome schooner built for Prof. Hyatt of the Fish Commission [*sic*] and to be used in helping the Prof. discover what the bottom of the sea is made of, a subject of great interest to the human race." It was a practice of the time among residents of Cape Ann to nickname vessels, especially those owned by summer visitors. Hyatt asked Adele Fielde, a pupil at the summer school and a famous missionary to China (author of *Under the Shadow of a Pagoda*), to suggest for his nearly square-ended catboat a name that could not be corrupted. Miss Fielde had the Chinese characters for *Solitary Wasp* painted on the stern, but the catboat was soon known as "Hyatt's Old Tea Chest." The *Arethusa,* a sketch of which appears on the bronze plaque at Norwood House, was taken on dredging expeditions over much of the New England coast, dredging to depths of more than 100 fathoms, and sailing as far north as Newfoundland and Labrador. She sailed under Captain Gilbert Davis.

* Acknowledgment is made to Mrs. Alfred G. (Harriet Hyatt) Mayor, daughter of Alpheus Hyatt, and Professor E. G. Conklin, of Princeton University, for their kind assistance and encouragement in bringing together the story of the Annisquam Sea-side Laboratory.

Home of Alpheus Hyatt on shore of Goose Cove at Annisquam where his Sea-side Laboratory originated (September 1949).

For the summer of 1881 a formally organized seaside laboratory was established for advanced students in connection with the Teachers' School of Science. According to the announcement, "The purpose of this laboratory is to afford opportunities for the study and observation of the development, anatomy, and habits of common types of marine animals under suitable directions and advice."[4] Each student worked independently under the direction of B. H. Van Vleck, assistant at the Museum of the Boston Society of Natural History and instructor at the Sea-side Laboratory. Twelve students were expected, but a total of twenty-two enrolled. Thirteen of these were teachers in the public schools of Boston or college instructors at various institutions. Four were investigators who came to pursue their own research. The Woman's Educational Association donated $400 for expenses and distributed advertising circulars. Neither the director nor the instructor was paid for his services since the Annisquam laboratory was now regarded as a department of the Boston Society and both men were in its employ. Much of that summer Hyatt was on a dredging expedition with the *Arethusa* to Anticosti Island, and the laboratory was placed in Van Vleck's charge. An interesting squib in the *Cape Ann Advertiser*[5] relative to the summer school that season reads as follows:

> The "Laboratory" has not obtruded much upon public notice. Unbroken stillness has reigned in and around it throughout the school term, and one would hardly be led to suppose that within its sacred walls, science is deducing from fish bones alone what would make Agassiz, were he living, want to climb a may pole. The big sea turtle caught at Folly Cove, and brought here for science to study and dissect, came very near emulating Sampson of old and slaying more in his death than in his lifetime. To understand how that might be, can be readily obtained by applying for information to the partakers of the "soup," many of whom, perhaps, dipped rather deep into the dish.

Sometime early in the history of this summer school, the laboratory was moved to a building situated nearby on a wharf at Lobster Cove. The demand for more laboratory space necessitated this move, although the records do not state the year when the change was made. In the season of 1882 a windmill, gift of the Woman's Educational Association, was erected to pump sea water into the laboratory. There were three large aquaria in the center of the main room and one aquarium at each student table. Fourteen students and one investigator were present. It was noted in the report of the curator that expense for room and board at a seaside resort was the most important obstacle to success, for at Annisquam the students and investigators lived as "summer boarders" in the community.

The season of 1883 was the least successful in the history of the school. Only ten students were registered, and the average time in residence for each was three and one-half weeks. Interest was reawakened the following year, however, with a total of fifteen in attendance. On July 16, 1884, the Essex County Institute held a field meeting at the labora-

Building on shore of Lobster Cove in which the Annisquam Sea-side Laboratory was located (July 1951).

tory, attended by 110 members. J. S. Kingsley, an instructor at the laboratory, outlined its history and purpose. He explained the system of independent study, the methods of field collecting, and the laboratory facilities. The main aim was stated to be to produce good teachers and investigators through proper methods of study. Drill in scientific methods was of greatest importance, and the work centered around the embryology of marine animals.[6] After this introduction, Hyatt "spoke of the philosophy of the instruction as distinct from the curriculum adopted in the various schools of learning" and then gave a scientific discourse on sponges.[7]

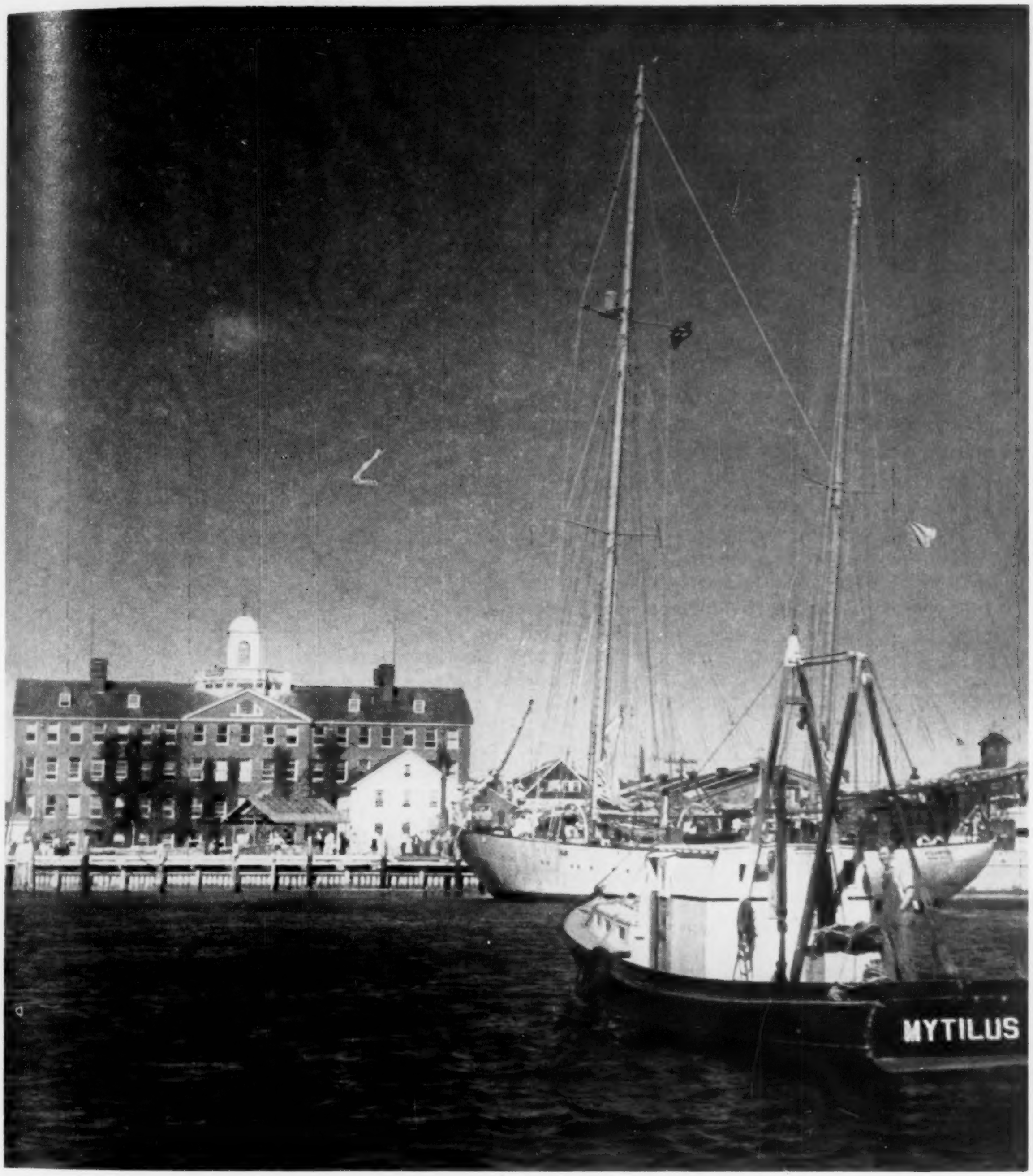
In his annual report as curator of the Boston Society of Natural History,[8] Hyatt pleaded for more substantial backing of the summer school, but also sensed that his plan was not wholly successful because many of the students were not so well prepared for independent work as had been assumed. He wrote: "This department has at length succeeded so far as instruction and personal effort can make success; the future depends upon other and more material supports. . . . The director has felt that his plan was open to criticism, on account of its novelty, for it differed from the ordinary plans of similar laboratories."

The season of 1885 attracted thirteen students, averaging four weeks and one day in attendance, but the following year the enrollment doubled, making it the most successful as well as the last season of the Annisquam Laboratory. The twenty-six students averaged thirty-four days at the station. One of these, destined to become one of America's foremost zoologists, was Thomas Hunt Morgan, who had just graduated from the University of Kentucky. During this final session Van Vleck was remunerated by the Woman's Educational Association for his services.

This experiment in science education had proved its value. However, the policy of the Woman's Educational Association was to support projects only until they became firmly established, leaving them to their own devices once they were fully organized. The association was more interested in developing new institutions than in supporting existing ones. Hence, after the summer of 1886, it no longer subsidized the seaside laboratory under the auspices of the Boston Society of Natural History. Also, Hyatt himself thought the time had come to place the laboratory on a more permanent and independent basis. In his annual report to the Boston Society[9] he wrote: "The steady gains and successes of this department are matters for congratulations, but the time had come for making an effort to found a distinct institution, one standing upon an independent foundation and consequently . . . it has passed out of our hands." Not only did he feel that a separate organization should be established, but he was prepared to seek a new site where the water would be purer than that of the Annisquam inlet.

Spencer Fullerton Baird was keenly interested in the Annisquam Sea-side Laboratory. For a period of several years he tried to persuade his friend Hyatt to have the summer school transferred to Woods Hole and operated in close association with the work of the U. S. Fish Commission.[10] Lack of funds on the part of all concerned—the laboratory, sponsors, and students—prevented the development of such a plan. Baird then established a permanent laboratory for marine research at Woods Hole in connection with the program of the Fish Commission, continuing the temporary stations that had been set up at Woods Hole in 1871 and 1875, and at other points during intervening years. In this he was assisted and encouraged by Alpheus Hyatt and several other interested persons. Dall[11] wrote, "Baird had not succeeded in interesting Congress in his proposed seaside school of biology or laboratory at Woods Hole. After his arrival there for the summer work, he had better success with private liberality. Wealthy men of Boston, Oliver and Frederick Ames and Montgomery Sears among them, offered the necessary funds." Baird invited students of zoology to carry out studies and research in the laboratory of the Fish Commission, which was established in 1882, giving them full cooperation in the use of its facilities. That summer the *Arethusa* was moored at Woods Hole. In 1885 a permanent building for the work of the Fish Commission was constructed.

In 1887 the Woman's Educational Association decided that an effort should be made to establish an independent marine biological laboratory and that at least $15,000 should be raised to support it for five years. A board of trustees was appointed to solicit subscriptions. Hyatt called a meeting of all interested in the project, and in March of 1888 the Marine Biological Laboratory was incorporated. Hyatt was elected president of the corporation, which office he held for two years. Of the ten incorporators, two others were also from the Annisquam Laboratory—B. H. Van Vleck, principal instructor, and Edward G. Gardiner, one of the original students. Hyatt and Gardiner served as trustees, the latter holding the office of Clerk of the Corporation for three terms. In addition, Thomas H. Morgan later served as a trustee of the Marine Biological Laboratory, and Adele M. Fielde, an-



Woods Hole Oceanographic Institution today is a familiar sight, beloved by two generations of biologists. Here the research vessel *Atlantis* comes alongside the dock after a North Atlantic cruise. Accompanied by the *Albatross III*, the *Atlantis* left last month for an investigation of the ocean between West Africa and the South American coast.

other Annisquam student, carried out her brilliant research on ants at the new laboratory. C. O. Whitman was chosen the first director of the Woods Hole laboratory, and Van Vleck was made the first instructor, continuing his work begun at Annisquam. The Woman's Educational Association donated to the Woods Hole laboratory all the equipment that had been supplied to the Annisquam station in addition to a grant of $800.

Thus the Woods Hole Marine Biological Laboratory grew out of the early experimental school at Annisquam. A number of people took part in establishing the permanent institution, but E. G. Conklin has stated in personal correspondence that

"Alpheus Hyatt was the real father of the Marine Biological Laboratory." Hyatt, former student of Louis Agassiz at the Lawrence Scientific School of Harvard and greatly influenced by him, devoted most of his life to the interests of zoology and paleontology, becoming eminent in both fields. In addition to his duties in teaching (Massachusetts Institute of Technology and Boston University), research (Museum of Comparative Zoology), and administration (Boston Society of Natural History), he took an unusually active part in creating institutions devoted to science. His organizational abilities led him to play a prominent part in founding the Agassiz Zoological Club at Harvard (1860); the Peabody Academy of Sciences (1867); the *American Naturalist* (1869);[12] the Teachers School of Science (1870); courses in biology, Boston University (1877); the Annisquam Sea-side Laboratory (1880); the American Society of Naturalists (first president) (1883);[13] and the Marine Biological Laboratory (1888).

In 1928 a bronze tablet prepared by Mrs. Alfred G. Mayor was placed in the reading room at Woods Hole portraying a bas-relief of Professor Hyatt and with the following inscription:

ALPHEUS HYATT

First President of the Woods Hole Laboratory 1888.
He also founded its prototype at Annisquam,
Massachusetts, established in 1880 with the aid of the
Woman's Educational Association and the Boston
Society of Natural History.
1838–1902

Remarks by E. G. Conklin and F. R. Lillie made on the occasion were published in SCIENCE,[2] and a reproduction of the bas-relief appeared in a biographical sketch by R. T. Jackson.[14] Memorials of Hyatt were published by his close associates (Morse, Packard, Putnam, etc.),[15] Packard,[16] and Brooks.[17]

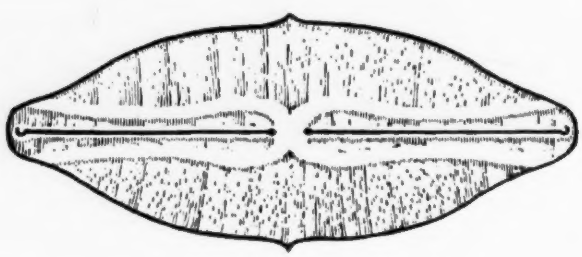
Hyatt's major contribution to the Woods Hole laboratory was bringing it into existence. Its direction and development soon passed to other and younger hands, the history of which has been related by Lillie.

RALPH W. DEXTER

Department of Biology
Kent State University
Kent, Ohio

References

1. LILLIE, F. R. *The Woods Hole Marine Biological Laboratory.* Chicago: Univ. Chicago Press (1944).
2. [CONKLIN, E. G., and LILLIE, F. R.] *Science,* 68, 291 (1928).
3. *Editorial.* [Anon.] *Cape Ann Advertiser* (July 16, 1880).
4. Report of the Curator. *Proc. Boston Soc. Natural History,* **22,** 9 (Annual meeting 1882).
5. *Editorial.* [Anon.] *Cape Ann Advertiser* (Sept. 16, 1881).
6. KINGSLEY, J. S. *Bull. Essex Inst.,* **16,** 149 (1884).
7. ANON. *Ibid.,* 147.
8. Report of the Curator. *Proc. Boston Soc. Natural History,* **23** (annual meeting May 6, 1885).
9. *Ibid.* (annual meeting May 4, 1887).
10. HYATT, A. *Proc. Boston Soc. Natural History,* 23, 558 (1888).
11. DALL, W. H. *Spencer Fullerton Baird.* Philadelphia: Lippincott (1915).
12. CONKLIN, E. G. *Am. Naturalist,* **78,** 29 (1944).
13. *Ibid.,* **68,** 385 (1934).
14. JACKSON, R. T. *Ibid.,* **47,** 195 (1913).
15. MORSE, E. S., *et al. Proc. Boston Soc. Natural History,* **30,** 413 (1902).
16. PACKARD, A. S. *Proc. Am. Acad. Arts Sci.,* 38, 715 (1903).
17. BROOKS, W. K. *Natl. Acad. Sci. U. S., Biog. Mem.,* **6,** 311 (1909).



LETTERS

A CRANK'S–EYE VIEW

LAURENCE J. LAFLEUR'S article in the November issue of THE SCIENTIFIC MONTHLY, called "Cranks and Scientists," impels us to write an answer for the other side. Being an old and experienced crank of the letter-writing variety, we feel that our experience with scientists, editors, and book publishers is such that we are well qualified to give a crank's-eye view of the average scientist.

In his article Dr. Lafleur has listed seven ways to identify a crank or a crank theory. He has accused the cranks of certain mental characteristics that set them apart from scientists, as well as from other men, and thus places upon them a certain stigma. It must be admitted that he has gone at the job in a pleasant manner and ended on a note of hope for their redemption. It is our hope to do as well for the scientists.

Being a crank and prone to come at any problem in a hasty manner, we at first thought to settle the whole matter by one simple test for the scientist—namely, to ask him a question and if he gives a straightforward answer, he is not a scientist. On further consideration, we decided this might cut out some of the fun, so we launch forth with the following diagnosis.

First, we must decide what manner of person a scientist is and who may qualify under the meaning of the term. The dictionary defines a scientist as "One versed in science or devoted to scientific study or investigation; a savant." This definition, it will be noted, says nothing about educational background. It is generally assumed, however, that an accredited scientist should have at least four years of college work in some field of science and that he practice his science to some extent. What kind of people, then, are those who come under this educational classification? What is typical of them, and how do they differ from the typical crank or layman?

Dr. Lafleur has said that there are all kinds of cranks, ranging from the very ignorant to the highly intelligent. What he did *not* say is that there are all kinds of scientists, from the very mediocre to the few top-flight men. If we were to single out the few scientists who have made great names for themselves by proposing and proving new theories, we would probably find that they are in no greater proportion to the whole body than the cranks who have made good in the same way. Probably not so numerous.

It is our observation that the great majority of people who deliberately decide to be scientists, and so educate themselves, are those who are psychologically unfitted to be real creative thinkers. They go into science because they are afraid to think for themselves. They lack self-confidence; they want to lean on the orthodox, the great authorities. The average scientist never dreams of questioning an authority. He takes for granted what he reads in his textbooks and rarely looks up their source material. Dr. Lafleur points up these latter facts, to our great delight, when he says that most scientists form their opinions from secondary sources, and that they depend to a great extent upon the editors and publishers to weed out those articles and books that are not authoritative. And that teachers and instructors, in selecting a textbook, usually glance through the table of contents, read a section or two to see if it is readable and sound, but rely for the most part upon the reputation of the author or publisher. What now, doctor! Is this the new scientific approach? It may be typical of many so-called scientists, but certainly not of the crank, who is always doubting authorities.

Another characteristic of the average scientist is his fear of making a mistake, of being found in error. Seldom will he make a positive statement or offer an opinion, even in his own field, and almost never in some other field of science. That's not cricket! Since the building of a new theory may require knowledge in several different fields of science, this fashion of thinking within narrow limits becomes a brake on the possibility of scientists' producing many new theories. Basically, however, the average scientist fears to be different; he fears to be called a crackpot or a crank. He may claim that he cannot afford to jeopardize his job or his professional standing, but actually he knows that he hasn't got what it takes. The true crank, on the other hand, is so sure of himself that he will risk fortune and family, everything! The scientist usually takes this as a sign of selfishness or ignorance or both. He decides that the crank's new world-shaking theory is the result of ignorance and he recommends certain books. Sometimes this has the desired effect, but as often as not the crank has already read the books and is sure they are wrong. This stops the scientist! He is flabbergasted! The conceit of this fellow who puts himself above the world authorities! It is beyond his comprehension. Living by authority himself, he cannot understand one who does not, and often cuts the crank off without even reading his arguments, so offensive is this egoism to him.

The crank seldom realizes that he is making himself offensive in this manner. His conceit is natural to him. He grew up that way and has never felt inferior to other people. He has no fear of making mistakes; not because he doesn't realize the possibility but because it wouldn't occur to him to be ashamed of it if he did make a mistake. This is a major requirement for anyone who would propound a new theory or do creative work. Edison, as everyone knows, was the outstanding example of a crank who made thousands of mistakes and cared not a whit what anyone thought or said. He had many of the characteristics of the crank and few

of the scientist, but perhaps the thing that set him apart and above the common crank was his wisdom in never writing letters to scientists, or going to scientists for approval of his ideas. This would have been a waste of time, and Edison was a doer. If a crank has any feeling of inferiority it is this one, that he must get the approbation of the scientist for his theory.

As a rule, cranks have little formal education, probably because of their natural ego, their certainty that they are destined to become second Edisons. Always in a hurry to succeed, they are impatient of any sort of laborious study of the commonplace. Hence, they seldom go to college and do the hard groundwork necessary to become a really great scientist.

Imagination is also a necessary ingredient in creative thinking. This is what the crank often has and the scientist often has not, so he resents the crank. Some scientists, of course, have plenty of imagination, but their training often makes them afraid to use it. They take nothing for granted. George F. Carter points this out in an article called "Man in America: A Criticism of Scientific Thought," in the same November issue of THE SCIENTIFIC MONTHLY. He says that it is the fashion among scientists to glorify a limited and unimaginative style of thinking. He illustrates his statement with a story about the layman and the scientist riding on a train. The layman gazed out the window and said, "Look at those newly shorn sheep!" The scientist, after some thought, said, "Well they *do* appear to be shorn on one side." This is typical of the average run-of-the-mill scientist. He considers himself a thinker or as belonging to a class of outstanding individuals who *are* thinkers. He has been trained to believe that conservatism and book knowledge are thinking and will somehow lead to the advancement of science without imagination. He will not allow himself to imagine what is on the other side of the sheep.

The average layman is apt to think of a scientist as the man who taught science in high school, or perhaps some college professor. He usually remembers this man as a mean or colorless individual (according to what grades he received) and almost never as a scientist who was investigating anything new or unusual. This lack of quality in our teachers is partly due to the low salaries paid but more to the fact that they are psychologically willing to accept low salaries. Most of them knew that they would never receive much when they went into the teaching profession. These are the people who spend their spare time playing bridge or reading mystery stories. They are not interested in science and probably never were. They have no desire to investigate anything, much less to criticize the contents of textbooks. Like the layman, they imagine that the scientists, somewhere, must have the right answers. The layman has been taught to venerate science, if not the teacher, and like the teacher he supposes that the books contain nothing but the truth and that the publishers somehow know enough to check up on the authors.

Lafleur argues that we cannot afford to discard accepted theory for new, when the great body of scientists agrees with the old; that we cannot ignore this great weight of scientific opinion. We should like to inquire how, if they refuse to think for themselves, they can be said to have an opinion or how it can carry much weight?

The greater part of Lafleur's article is devoted to a discussion of Velikovsky's book *Worlds in Collision.* He uses it to illustrate how much time and trouble may be required of a scientist to refute a crank theory, and thus excuses all scientists for not answering crank letters. He claims that scientists are too busy to give the time and that the cranks could get the answers if they would only read the right books in the libraries. This is probably true as to the great majority of crank theories, but there are some which, in whole or in part, cannot be so easily turned aside. In our opinion, it is not fair nor scientific to cast aside all a crank's work because a part of it, or even most of it, is invalid. It is easy to point out the glaring examples of bad science and to ignore the questions for which science has no answer. This is the way in which Lafleur has criticized *Worlds in Collision.* He concentrates on Velikovsky's theories that the planets Venus and Mars slipped out of their orbits, made several passes at the earth, and returned to their orbits; how the earth stood still and then resumed its motion; etc. These things are easy to refute, and he did a good job of it. He made one mistake himself, however, although he hedged with the word "practically."

In applying "Test 2," Lafleur makes the following statement: "The collision theory is in fundamental contradiction with practically every tenet of mechanics, both classical and modern, to which Velikovsky adds occasional disagreements with other branches of physics." He makes this broad statement without saying what these tenets are and then goes on to belabor Velikovsky for using myths and legends to prove his near-collision theory. It must be remembered that Velikovsky did not postulate actual collision but only close approaches. Actual collision between the earth and smaller cosmic bodies is an absolute and undeniable fact, as certain and as susceptible of proof as any physical law of science. Small meteorites have been seen to strike the earth hundreds of times, and the great Siberian fall in 1908 shook the earth for several hundred miles around—but not many of our scientists. Now that larger and larger craters are coming to light, such as the Wolf Creek Crater in Australia and the Chub Crater in northern Quebec, scientists are not quite so sure that no object greater than a few hundred tons has ever struck the earth. There is no law of celestial mechanics (classical or modern) that can deny this fact, yet scientists (especially geologists) have refused to consider the possibility. When confronted with a whole book full of physical evidence (not just theory), they refuse to consider it or discuss it in any way. They refuse to examine the other side of the sheep.

When we go to the libraries to discover what the

books say (since the scientists are too busy to make reply), we find something like this: Since no major collisions have occurred on the earth within the past few thousand years of recorded history, it is concluded that nothing of the kind has ever happened. Also, they say, why should the scientist call upon cataclysmic forces to account for earth features if ordinary processes working over long periods of time will account for the phenomena?

In answer it may be said that the few thousand years of recorded history are only a grain of sand on the shore of time and not a fair or scientific sample of all time. The fact that no major collision has occurred on the earth within the past few thousand years does not prove that such cataclysms have never happened. The facts are that the evidence of collision is much greater and more positive than the evidence of uniformity. The ordinary processes of erosion working over long periods of time will *not* account for all the earth phenomena, many of which show every sign of sudden and violent catastrophe.

Here, then, is a new and revolutionary theory that will pass all Dr. Lafleur's tests except the seventh. In this test Dr. Lafleur asks: "Does the proposer show a disposition to accept minority opinions, to quote individual opinion opposed to current views, and to overemphasize the admitted fallibility of science?" It appears to us that this test is unfair and can only be answered in the negative by the proposer of any new theory. Since the majority of scientists are almost certain to oppose any new and revolutionary theory, it follows that the proposer has nothing left to quote. He therefore would be forced to give nothing but his own opinions and make himself liable to criticism for egotism and lack of outside scientific support. This is quite a burden to place upon anyone advancing a new theory, for even the scientist would be required to appeal to individual views and minority opinions if he were to advance a new theory.

In the final analysis, it is very difficult for anyone to view objectively, whether he be crank or scientist, the facts and philosophies of this world. If we may end on a note of hope, then, it is this: that the scientists will look more objectively upon the cranks and their theories and that the cranks will not overemphasize the fallibilities of the scientists.

ALAN O. KELLY

Carlsbad, California

ASSOCIATION AFFAIRS

A BRIEF REPORT OF THE PHILADELPHIA MEETING

THE actual attendance at a AAAS meeting can never be more than a close estimate, because practically all the sessions, especially the evening lectures, are open to the public. Useful indexes, however, are paid registrations and the complimentary tickets for admission to the Annual Exposition of Science. The detailed registration slips, taken from the Visible Directory, permit analyses of the home states and fields of interest of the registrants.

The number of registrants was 3,702, making this larger than any previous meeting in Philadelphia. This figure is particularly impressive when it is considered that the 3,339 registrants of the 1940 AAAS Meeting in Philadelphia were there to attend annual meetings of their own societies. This was true of the physicists, astronomers, entomologists, parasitologists, botanists, phytopathologists, geneticists, and horticulturalists, none of whom held their annual meetings with the AAAS in 1951. From Table 1, it will be noted that, as in 1950, every state in the union was represented, with the sole exception of Nevada (which, however, always has proportionately good representation at the summer meetings of the Pacific Division).

There were 37 registrants from outside of the continental United States: 20 from Canada; two each from Brazil, Italy, and Puerto Rico; one each from Alaska, Cuba, East Africa, England, France, Germany, India, Norway, Thailand, Uruguay, and Venezuela.

Another index of total attendance at a AAAS meeting is the number of complimentary admission tickets to the Annual Exposition of Science and Industry, which are (1) distributed to members of scientific and professional groups who request them, either directly from the AAAS or through their local societies; or (2) given to exhibitors to send to preferred potential customers and to key members of their own organizations. The total number of tickets given out by the AAAS each year averages 10,000, about 40 per cent of which may be filled out with sufficient information about the user for analysis of subject interests. At Philadelphia the system of metering all those who had complimentary cards of admission, or ensuring that their names, addresses, and fields of interest were properly recorded, could not be enforced. Nevertheless, a substantial number of such cards completely filled out was available at the end of the meeting. The fields of interest on these cards have been combined with those of the 3,702 registrants (Table 2).

TABLE 1

Distribution of Registrants by States

Pennsylvania	1171	Minnesota	17
New York	510	South Carolina	17
New Jersey	343	Louisiana	15
Maryland	203	New Hampshire	14
District of Columbia	185	Alabama	13
Massachusetts	179	West Virginia	12
Illinois	115	Kentucky	11
Ohio	102	Vermont	11
Virginia	90	Colorado	10
Michigan	79	Nebraska	10
Connecticut	73	Maine	8
Delaware	71	Mississippi	8
Indiana	59	Washington	8
North Carolina	43	New Mexico	4
Tennessee	37	South Dakota	4
Florida	36	Montana	3
Texas	30	Oklahoma	3
California	27	Wyoming	3
Missouri	26	North Dakota	2
Rhode Island	26	Utah	2
Iowa	21	Arizona	1
Kansas	21	Arkansas	1
Wisconsin	20	Idaho	1
Georgia	19	Oregon	1
		Total	3665

Subject fields are not as readily analyzed as geographical data. Some registrants will list as their field of interest a narrow research specialty, whereas others may name two or more major sciences. In the first case, it is nearly always possible to tabulate the specialty under a broader scientific field and, in the second instance, it seems safe to assume that the field first named is the primary interest. It will be noted that the biological sciences, collectively, and the medical sciences, together, comprised about half the attendance at the 118th Meeting; the physical sciences, between one fifth and one quarter; and the engineering and the social sciences, each close to one tenth.

Whether these proportions are typical of all AAAS meetings is a natural question, which cannot be answered definitely for want of sufficient data over a period of years under varying conditions. It is believed, however, that, within the broad classifications used, and for the next few years, these percentages will not vary greatly. Since the Association meets in large cities which contain one or more large institutions of higher learning, medical schools, experiment stations, and industrial laboratories, a good-sized local and regional attendance is assured at the outset. Thus, a AAAS meeting, under normal conditions, can be expected to have 2,500–4,500 registrants, plus an additional number of local professional people, totaling 1.6 times the number of registrants—or a minimum attendance of 4,000 and a potential maximum of 12,000.

TABLE 2

Subject Fields of the Attendance at Seventh Philadelphia Meeting

Physical Sciences		22%
Physics	345	
Chemistry	484	
Geology	176	
Engineering		9%
Biological Sciences		27%
Botany	235	
Zoology	545	
Other Biology	448	
Medical Sciences		21%
Dentistry	140	
Pharmacy	102	
Other Medicine	739	
Social Sciences		9%
Education, Social Sciences	436	
General		12%
General Interest in Science	530	

For section secretaries and other program chairmen who want their programs and symposia to be well attended, there is a simple formula for success: (1) Invite the advice of the entire section committee, perhaps others, regarding the subject those in that field would most like to hear; (2) early in the year (before other engagements may have been made) invite recognized authorities to participate, indicating both the scope of the symposium and the names of the others who are being asked; (3) secure firm commitments by June 1, in time to make it possible for appropriate scientific journals to announce the program; (4) send mimeographed or other announcements to every department or laboratory that has faculty, researchers, and students who should hear that symposium (rather than read it), meet the speakers, perhaps contribute to the discussion at the session.

The 118th Meeting was important on more than one count. The Association's two general symposia were out of the ordinary in importance and significance. The symposium on "Soviet Science" was concerned with an objective appraisal of the quality of science in the Soviet Union at this time. The widely sponsored three-session symposium, "Operation Knowledge," near the end of the meeting, focused attention upon the deficiencies in the communication of concepts, in all media, in today's complex society.

The special sessions—outstanding general addresses and even lectures by eminent authorities, sponsored jointly by the Association and organizations that meet regularly with the AAAS—were up to the high standard of previous years. In chronological order, these were: The annual address of the Society of the Sigma Xi, "Animal Light," given by E. Newton Harvey, Henry Fairfield Osborn professor of biology, Princeton University; the annual address of the Scientific Research Society of America, "The Human Element in Industrial Research," given by E. W. Engstrom, vice president in charge of research, Radio Corporation of America; the annual illustrated lecture of the National Geographic Society, "An Ornithological Expedition to Nepal," delivered by S. Dillon Ripley, Peabody Museum, Yale University; the one-hundredth AAAS presidential address, "Man's Synthetic Future," given by retiring president Roger Adams; and the annual address of the United Chapters of Phi Beta Kappa, "Science and Man's Destiny," by Arthur H. Compton, president, Washington University. The final special session was the revival of an annual address by the Honor Society of Phi Kappa Phi. The speaker, Cornelus W. de Kiewiet, president, University of Rochester, spoke on "Our Human Resources of Skill and Wisdom," before a small but enthusiastic audience.

Safety in the Chemical Laboratory

A party-line automatic artificial respiration system can administer oxygen to six persons at once. Pneophore, developed by Mine Safety Appliances, administers the oxygen from high-pressure storage tanks outside the dispensary, in accordance with the patient's breathing cycle or at regular predetermined intervals if the victim is not breathing.

A lightweight goggle, made of clear or green plastic, may be worn over prescription glasses and will protect against flying particles, splashes, chips, dust, and glare. A molded rubber binding ensures comfort and good fit.

Dust masks of a vegetable fiber will not dissolve in water or live steam, are washable and sturdy, and so inexpensive that they may be discarded after being used once. They will protect against nuisance dusts but not against toxic dusts, silica, or fumes.

Emergency Equipment

Disposable oxygen masks, for commercial use only, are low in cost and light in weight. The masks can be quickly connected to an airliner's oxygen system for passengers requiring oxygen or in case of cabin pressure failure.

Automatic emergency light plugs into any 110-v, a-c outlet and will come on instantly if there should be any interruption in the regular lighting circuit. Unit is self-contained, portable, and adjustable in any direction.

Publications Noted

Acta Gerontologica, Vol. 1, No. 1, January–February 1951. Published in Milan. Clinical editor, C. Vallecorsi; editor for morphology, C. Cavallero. 3,600 lire per year.

The Summary, Vol. 2, No. 1, May 1950. Formerly *The Seminar*. Published by the Shute Foundation for Medical Research, London, Canada.

Water in Industry. A Survey of Water Use in Industry. National Association of Manufacturers and the Conservation Foundation, New York. Dec. 1950.

Looking on as seven-year-old Tony Merck breaks ground for a new building that will expand research facilities of the Merck Institute for Therapeutic Research at Rahway, N. J., are Hans Moliter, director of the institute; A. N. Richards, a Merck director and former president of the National Academy of Sciences; and George W. Merck, Tony's grandfather. Shown below is architect's sketch of the new building, to be completed next September.